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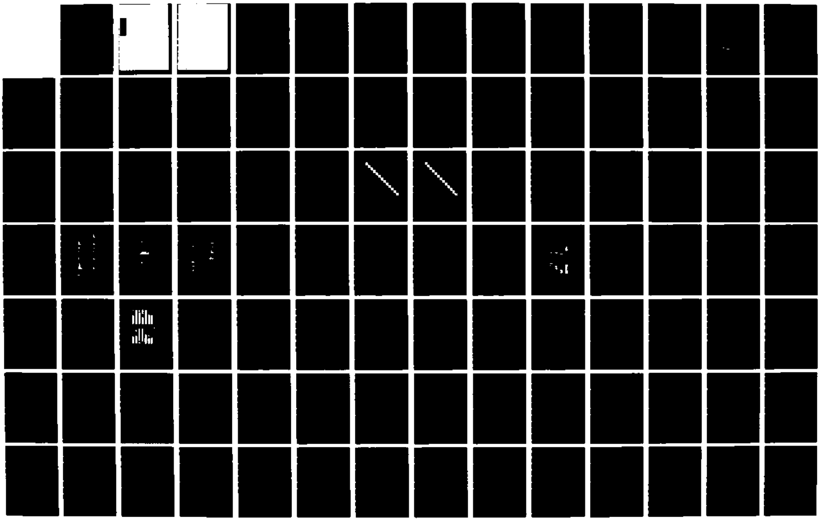

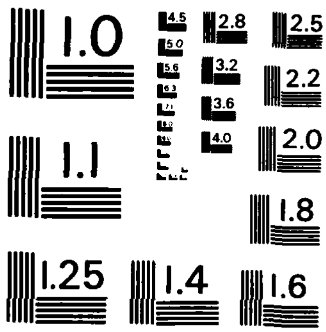

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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Few natural banks remain on the

12

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This report describes fish and benthic macroinvertebrate composition in five aquatic habitat types within Pool 5, river miles 89-102, of the McClellan-Kerr Arkansas River Navigation System. Two dike fields, including the dike structures themselves, two secondary channels, two natural banks, two revetted banks, and one abandoned channel were sampled during high- (June, >125,000 cfs) and low- (September, <10,000 cfs) flow periods during 1982.

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20. ABSTRACT (Continued).

Within each sampling period, relatively small differences were observed among habitats in terms of dissolved oxygen, temperature, pH, and conductivity. During the June high-flow period, both current velocity and substrate composition varied considerably, with habitats located nearer the upstream end of the pool tending to have swifter currents and coarser substrates. During the September low-flow sampling, pooled conditions existed and current velocity and substrate were homogeneous.

Fish populations differed most among habitats during the June high-flow period, when the habitats were physically most distinct. Fish species composition was primarily a function of current velocity. Habitats characterized by higher velocities (the upstream-most revetted bank, natural bank, dike field, and secondary channel) supported primarily catfishes and freshwater drum. Habitats with slower, or slack, currents (downstream-most revetted bank, natural bank, dike field, and secondary channel, plus the abandoned channel) also included typical slack-water species (sunfishes, basses, crappies, gars, bowfin). During the September low-flow period, fish populations showed little difference among habitats, reflecting the increase in habitat physical similarity.

The macroinvertebrate fauna colonizing the dike and revetment structures reflected the differences in physical conditions which existed in the study area during June. Those structures located near the upstream end of the study area were colonized principally by hydropsychid caddisfly larvae (Trichoptera), which are filter feeders and are therefore dependent upon current. Those structures located near the downstream end of the study area where currents were reduced exhibited a shift in dominance with polycentropodid caddisfly larvae and the Chironomidae (Diptera) constituting a majority of the benthic community in these habitats. This phenomenon, whereby different community composition could be directly correlated to varying current velocity, became more evident when comparing the fauna colonizing these structures in September to the community that had colonized the same habitats in June. With the absence of current in September, a typically lentic community existed at all habitats, with polycentropodid caddisfly larvae, the Chironomidae, and amphipods (Amphipoda) being the dominant groups collected at all habitats regardless of their location within the study area.

The benthic communities that colonized the bottom substrates differed most among habitats during the June sampling effort due to the extreme differences in current velocities and substrate types present at the various habitats. Those areas subjected to high current velocities and erosional substrates (dike fields and natural banks) had low density estimates and little diversity as compared to those habitats (secondary and abandoned channels) in which little or no current existed and a relatively homogeneous substrate was present. Tubificid Oligochaetes (Oligochaeta) and the Chironomidae (Diptera) were the dominant macroinvertebrate groups collected at all habitats in June.

Increases in density and diversity were noted for all habitats sampled in September as compared to June, with the natural bank habitat exhibiting the highest density estimates of all habitats sampled. This was due in part to the extremely high numbers of the amphipod *Corophium lacustre* (Amphipoda) collected at this habitat. The increase in density estimates and similarity among habitats in September is explained in part by the fact that physical conditions encountered during this time were somewhat similar in all habitats, unlike June when physical differences were observed over the entire length of the study area.

PREFACE

The study described in this report was sponsored by the Office, Chief of Engineers (OCE), US Army, under the Environmental and Water Quality Operational Studies (EWQOS) Program, Work Unit VA, Environmental Impact of Selected Channel Alignment and Bank Revetment Alternatives in Waterways. The EWQOS Program has been assigned to the US Army Engineer Waterways Experiment Station (WES) under the direction of the Environmental Laboratory (EL). The OCE Technical Monitors for EWQOS were Mr. Earl Eiker, Dr. John Bushman, and Mr. James L. Gottesman.

This report presents results of a study designed to document the distribution and relative abundance of fish and macroinvertebrates associated with different habitats found within the main-line levees along the Arkansas River. Fish and macroinvertebrates were collected from the river between miles 89 and 102 from June through September 1982.

The report was prepared by Mr. Larry G. Sanders, Mr. John A. Baker, Miss Carolyn L. Bond, and Dr. C. H. Pennington under the supervision of Dr. Thomas D. Wright, Chief, Aquatic Habitat Group; Mr. Conrad J. Kirby, Chief, Environmental Resources Division; Dr. Jerome L. Mahloch, Program Manager, EWQOS; and Dr. John Harrison, Chief, EL.

Special appreciation is expressed to Mr. Ed Bowles, University of Southern Mississippi, and Dr. David C. Beckett and Messrs. Tim Bosley, David Nelson, C. Rex Bingham, and Michael E. Potter, EL, WES, for field support. Mr. A. Dale Magoun, Northeast Louisiana University, is thanked for assistance with data analyses.

During the preparation of this report, COL Tilford C. Creel, CE, and COL Robert C. Lee, CE, were Commanders and Directors of WES and Mr. F. R. Brown was Technical Director. At the time of publication, COL Allen F. Grum, USA, was Director and Dr. Robert W. Whalin was Technical Director.

This report should be cited as follows:

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CONTENTS

CONVERSION FACTORS, US CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

US customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	4046.873	square metres
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres

BIOTA OF SELECTED AQUATIC HABITATS OF THE McCLELLAN-KERR ARKANSAS RIVER NAVIGATION SYSTEM

PART I: INTRODUCTION

1. The basic objective of the Environmental and Water Quality Operational Studies (EWQOS) Program is to provide new or improved technology for the planning, design, construction, and operation of Corps of Engineers (CE) projects in an effort to solve selected environmental quality problems. One major problem area identified by CE field offices as being of high priority involves the environmental impacts of project activities on waterways (Keeley et al. 1978). Specifically, it was determined that EWQOS research should develop field office guidance to address environmental features of dikes and revetments because such structures are integral parts of waterways in many parts of the United States.

2. This study, on a portion of the McClellan-Kerr Arkansas River Navigation System, was designed to assess the biota of various aquatic habitats, including dikes and revetments, utilizing methodologies developed during the early phase of the EWQOS Program, and to determine if the ecological relationships found on the Lower Mississippi River also occur in other river systems where navigation structures are common. Previous EWQOS studies addressing these concerns have been performed on the Lower Mississippi River (Pennington et al. 1980; Mathis et al. 1981; Beckett et al. 1983; Conner, Pennington, and Bosley 1983; Pennington, Baker, and Bond 1983), the Missouri River (Burress, Krieger, and Pennington 1982), and the Tennessee-Tombigbee Waterway (Pennington et al. 1981). Smaller-scale studies investigating particular aspects of CE project features include Mathis, Bingham, and Sanders (1982) and Bingham, Cobb, and Magoun (1980).

PART II: STUDY AREA

General Description

3. The 1450-mile*-long Arkansas River has its source on the eastern slopes of the Rocky Mountains in Colorado and runs generally southeastward to meet the Mississippi River in Desha County, Arkansas. Prior to construction of the McClellan-Kerr Arkansas River Navigation System, begun in 1957 and completed in 1970, the river flowed in a wide, shallow, braided, and variable channel. The river was charged with sediment and provided for little navigation beyond the lower few miles. Since completion of the navigation system, the river has been stabilized in its course, erosion and turbidity have been greatly reduced, and a minimum-size navigation channel has been available on a year-round basis.

4. The Arkansas portion of the navigation system consists of 12 lock and dam complexes. The two dams farthest upstream impound Lakes Dardanelle and Ozark (10,000 to 36,000 surface acres); the remaining dams impound little more than the original river channel. The channel in this portion has been stabilized to a minimum 250-ft width and 9-ft depth by a series of dikes, revetments, and cutoffs, in addition to the dams.

5. The area selected for sampling was located between navigation miles 89-102 within Pool 5 of the Arkansas portion of the navigation system (Figure 1). Pool 5 was chosen because it contained representatives of all the habitat types of interest. The water-surface slope and elevation in this reach of the river are controlled by the dams to maintain year-round navigable depths within each pool. Control of the river by these dams produces changes in the aquatic habitats as a function of both discharge and location.

6. During low- and moderate-flow seasons (0-70,000 cfs, July-January), currents within the pools are usually slack to slowly flowing (0-2 fps currents in the navigation channel), and surface elevations (above mean sea level (msl)) of upstream and downstream portions of

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* A table of factors for converting US customary units of measurement to metric (SI) units is presented on page 3.

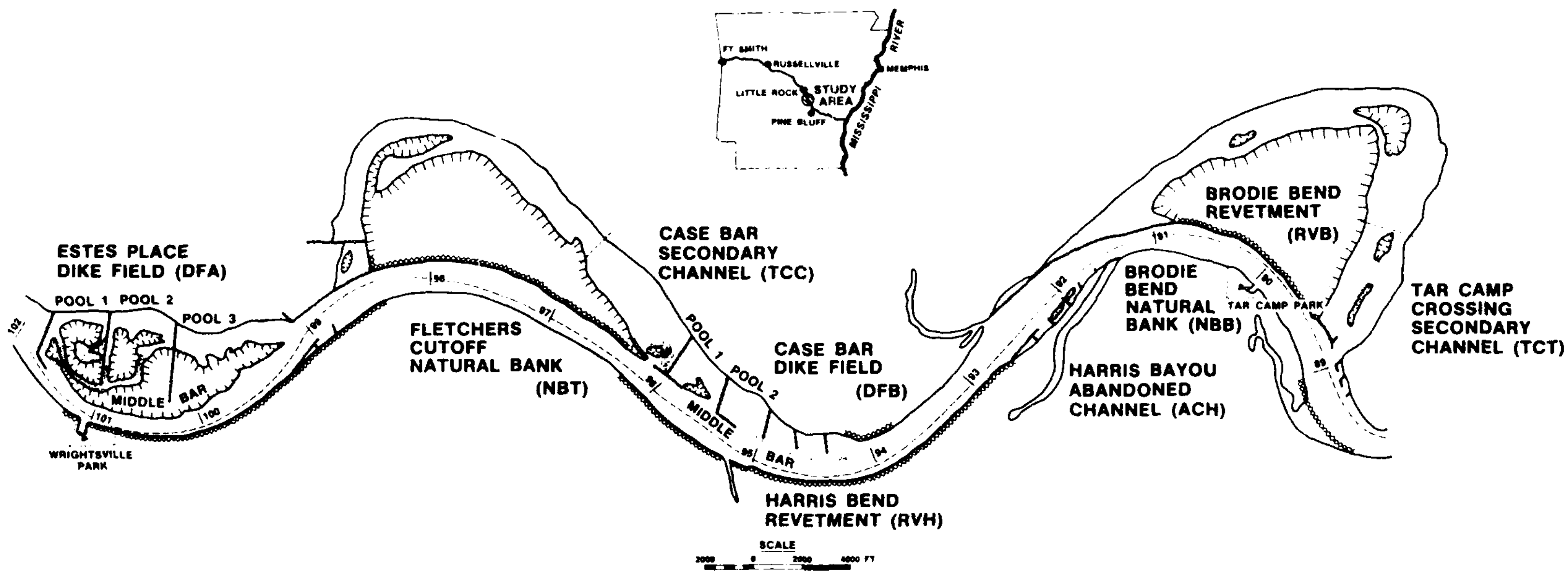

Figure 1. Pool 5 of the McClellan-Kerr Arkansas River Navigation System showing locations of study habitats. The dotted line indicates the position of the main navigation channel

individual pools are similar. At higher flows (greater than 70,000 cfs, February-June), current velocities can range from 2-10 fps and are considerably greater in the upstream portion of each pool. At such times, water-surface elevations of upstream areas can exceed those in downstream portions of the same pool by as much as 8 to 10 ft (Figure 2).

7. Above approximately 150,000 cfs, all lock and dam gates are opened, at which time the river exhibits a nearly uniform surface slope,

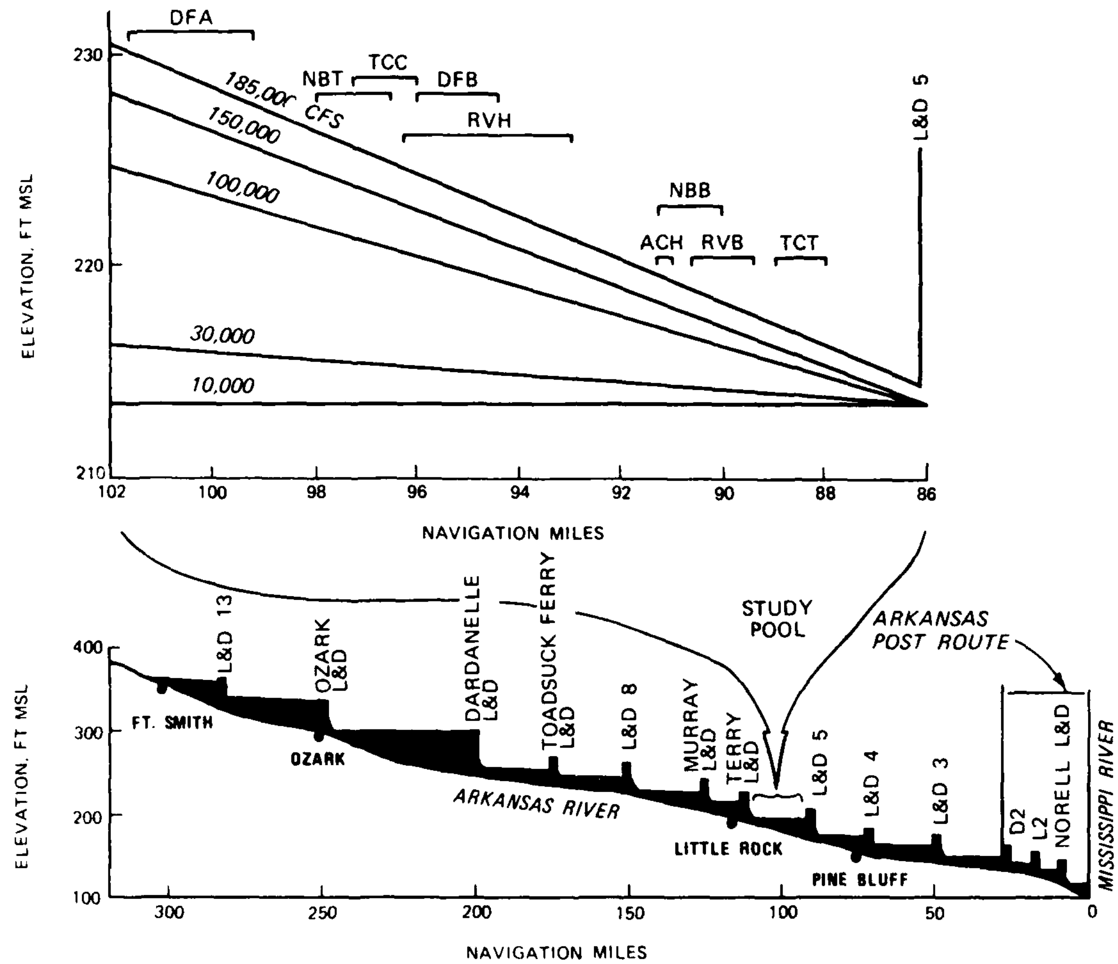

Figure 2. The relationship of surface elevation to discharge for Pool 5 of the McClellan-Kerr Arkansas River Navigation System. Acronyms in the upper graph refer to aquatic habitat types defined in Figure 1

as opposed to the "staircase" situation of low flows (Figure 2). The increase in surface elevation at moderately high discharges inundates low portions of upstream habitats and increases aquatic habitat area. Very little additional habitat is inundated in downstream sections. Water-current velocities in all habitats are slack at lowest discharges, but at higher discharges, upstream habitats have generally higher average current velocities and greater ranges of velocities than downstream habitats.

Habitats

8. Results of earlier CE investigations (Pennington et al. 1980, 1981; Pennington, Baker, and Bond 1983) indicated that several habitats should be sampled in order to adequately describe the biota of large river systems. In this study nine sites, representing five habitat types, were selected for study: two dike fields; two secondary channels; two natural banks; two revetted banks; and one abandoned channel. The habitats and specific sites are discussed in detail below.

Dike fields

9. Dike fields on the Arkansas River consist of two or more stone or stone and pile dikes placed perpendicular to the bank, the areas immediately downstream of these dikes (hereafter called dike field pools), and the middle bar which forms along the outer ends of the dikes. The middle bar may be either submerged or emergent. Dikes may be either straight (spur dikes) or L-shaped (L-head dikes). In the fish portion of this study, each dike field was divided into three separate subhabitats to facilitate statistical treatment: two individual pools and the navigation channel edge (river side) of the middle bar, hereafter referred to simply as the middle bar. Data from each subhabitat were compiled and analyzed separately. This separation was not necessary for the macrobenthos and water quality data sets.

10. Estes Place dike field (DFA). This dike field, at navigation miles 99.2-101.7 (L),* consisted of three stone and pile dikes (one

* (L) denotes left descending bank; (R) denotes right descending bank of the river.

L-head and two spur), three well-defined dike field pools, and an extensive, emergent middle bar (Figure 1). During June the water overtopped the dikes and a current of 1-4 fps existed in most areas; no current was present in any area (including the main channel) during September. The substrate of the dike field pools and of the middle bar consisted mostly of sand with patches of gravel or silt during June, with the exception of a large area of mud substrate occurring within Pool 1. During September the middle bar substrate consisted of sand and patches of gravel overlaid with thin layers of silt in some areas. Pool substrates were predominantly fine sands and silts, with some areas of mud. Sampling depths in the pools generally ranged up to 15 ft; however, scour holes up to 35 ft deep just below the dikes were also sampled. Middle bar depths sampled ranged up to 15 ft. Pools 1 and 3 were selected for sampling in this study, because Pool 2 was inaccessible by boat at low flows.

11. Case Bar dike field (DFB). This dike field, located at navigation miles 94.4-96.0 (L), consisted of two long, L-head dikes and three shorter spur dikes (Figure 1). Pools 1 and 2 were considerably larger than Pools 3-5, and were the two pools sampled during the study. The middle bar extending along the dike field was submerged even at low flows, except for a small, wooded island bordering part of Pool 1. During June, current speeds ranged from 1 fps along the shoreline to nearly 5 fps along the middle bar; no current was present in September. Substrate composition in all areas was predominantly sand during June and sand-silt during September. Sampling depths ranged up to 14 ft in most parts of the pools, but the scour holes that were sampled immediately downstream of the dikes were 20-35 ft deep. Depths sampled along the middle bar were 10-20 ft in June and 3-10 ft in September.

Secondary channels

12. Secondary channels are flow paths within a river which are subordinate to the main channel in flow capacity. A current exists at high and moderate discharges, but these habitats may become slack at low flows. The two secondary channels sampled in this study are former river bends that were cut off to create a shorter navigation route. The upstream ends are blocked by low stone dikes that allow water to pass through the

secondary channels at high and moderate flows, but divert all water through the navigation channel during low flows.

13. Case Bar secondary channel (TCC). This habitat extended from navigation miles 98.6 (L) to 96.0 (L) and was adjacent at the downstream end to Pool 1 of Case Bar dike field (Figure 1). The sampling area was restricted to approximately a 1-mile-long area at the downstream end. Sediments were predominantly sand and silt during June, when current speeds were from 1-3 fps. During September, slack-water conditions prevailed and a considerable amount of silt had been deposited. Depths sampled ranged up to 14 ft.

14. Tar Camp Crossing secondary channel (TCT). The upstream end of this habitat, at navigation mile 91.3 (L), was separated from the river at discharges less than 185,000 cfs by a stone dike. The downstream end, at navigation mile 89.2, was also partially blocked by a dike that extended about halfway across the entrance (Figure 1). This dike was submerged at all flows, however, so that passage by fishes and recreational craft was not impeded.

15. As with Case Bar secondary channel (TCC), the sampling area within this habitat was restricted to approximately 1 mile of the downstream end. A narrow, shallow area (0-3 ft deep) extended down the middle of this habitat, forming islands in two places (Figure 1), and gently sloping, shallow areas bordered each bank. Elsewhere, depths were from 5-12 ft. No current was detectable during either sampling period. The substrate consisted of fine sands and heavy deposits of silt, with some areas of mud. Fallen brush, trees, and other riparian vegetation provided underwater cover along most of both banks.

Natural and revetted banks

16. Revetted banks are sections of streambanks that have been armored with stone riprap to prevent erosion. Natural banks are sections of banks that have not been so stabilized. Revetted banks are usually graded to a 3H:1V slope before placement of the riprap (Keown et al. 1977), whereas natural banks often tend to be more nearly vertical and are often relatively deep close to the bank. Sloughing occurs frequently on natural banks, often resulting in a considerable amount of

fallen brush and trees in the water. Few natural banks remain on the Arkansas River; those selected for sampling in this study are actually cutoffs that were formed when the two secondary channels were bypassed for navigation purposes approximately 20 to 25 years ago.

17. Natural banks. Fletchers Cutoff natural bank (NBT), navigation miles 96.4-98.4 (R), and Brodie Bend natural bank (NBB) (as noted above, also actually a cutoff), miles 90.3-91.3 (R) (Figure 1), have steep, sloughing banks and a considerable amount of underwater structure in the form of fallen trees and brush. Depths along these banks range from 6-20 ft. Substrates were predominantly sands and clays, with accumulations of silt and leaf litter in backwater areas. Current speeds ranged from 2-4 fps during June; no current was present in September. Bank erosion at NBB was so severe that approximately 0.25 mile of the downstream portion was revetted just prior to the September sampling, thus eliminating approximately 25 percent of this habitat.

18. Revetted banks. Harris Bend revetment (RVH), navigation miles 92.8-96.3 (R), and Brodie Bend revetment (RVB), miles 89.4-90.8 (L) (Figure 1), were constructed of stone riprap placed on banks graded to approximately a 3H:1V slope. Extensive herbaceous and woody vegetation has become established on the riprap in many areas; this vegetation is partly inundated at high-water stages. Substrate consisted entirely of riprap during June. During September, however, considerable silt and algae had accumulated on the riprap. Current speeds ranged from 3-5 fps during June, but no current existed during the September sampling. Depths sampled ranged from 6-15 ft.

Abandoned channels

19. Abandoned channels are old river courses through which water no longer flows except at the very highest discharges. They differ from secondary channels in that they normally are connected to the river only at the downstream end. The substrate is almost entirely mud, with woody debris, standing timber, and stumps common to abundant throughout. One abandoned channel, Harris Bayou (ACH), was selected for this study. This habitat was confluent with the navigation channel only at navigation mile 91.4 (R). A low stone dike was constructed across the entrance at

this point, but it remained submerged several feet even at low river stages. The bayou was approximately 1.5 miles long, averaged 75-100 ft in width, and ranged in depth from 4-8 ft. Considerable standing and fallen timber was present except in a 20- to 30-ft-wide channel near the center. Mud was the predominant substrate. Currents averaged 1 fps in June, indicating that water may have been entering from the river upstream through a small feeder creek; no current was detectable in September.

PART III: MATERIALS AND METHODS

Sampling Periods

20. Fish, macroinvertebrate, and water quality samples were collected during a high-discharge period (10-20 June) and a low-discharge period (15-25 September 1982), with one exception. Due to the high June discharges, rock basket samplers (described below) could not be retrieved until July. Discharges at Lock and Dam 5, which impounded the study pool, were 143,000-156,000 cfs during the June sampling and 1000-8700 cfs during September.

Transect and Station Designation

21. Sampling stations within each habitat were located by superimposing a grid system over the habitat and randomly selecting points at which to set nets, begin electroshocking, take benthic grabs, or monitor water quality. The grid lines running perpendicular to the shoreline were identified by lettered markers that were placed alphabetically from upstream to downstream in each habitat. Sequentially numbered station lines were located at intervals along, and perpendicular to, these transect lines, beginning at the shoreline and extending across the habitat.

22. Intervals between transect and station lines varied with the size of the habitats. In the dike fields, lettered transects were situated at 500-ft intervals along the shoreline. Station line intervals were 50 ft in Estes Place dike field (DFA) and 200 ft in Case Bar dike field (DFB). Transect and station lines were located at 1000-ft and 500-ft intervals, respectively, in Case Bar and Tar Camp Crossing secondary channels (TCC and TCT). In the abandoned channel (ACH), transects were separated by 500 ft and stations by 20-50 ft. Transect intervals were 1000 ft along Brodie Bend natural bank (NBB) and Brodie Bend revetment (RVB), and 1500 ft along Fletchers Cutoff natural bank (NBT) and Harris Bend revetment (RVH) (Figure 1) so that the entire length of each habitat would be sampled. A single station near the shoreline was sampled along each bank habitat transect.

Sampling Gears and Procedures

Water quality

23. Hydrolab readings were collected in both early morning and late afternoon at from 2-4 stations in each habitat on both the first and last days of each sampling period. Temperature, dissolved oxygen concentration, conductivity, and pH were measured at 1 m below the surface and 0.5 m above the bottom. If the depth exceeded 3 m, an additional set of readings was collected from middepth. In the scour holes below the dikes, two intermediate readings were obtained, at one-third and two-thirds of the way between the surface and the bottom.

Fish

24. Previous studies of gear selectivity have indicated that while certain gear types might adequately capture specific species or a certain size range of fish, no single gear is adequate for capturing all sizes of all species found in large river systems (Starrett and Barnickol 1955, Funk 1958, Pennington et al. 1980). For this reason, four of the gears found to be most efficient in larger rivers (Pennington et al. 1980, 1981; Pennington, Baker, and Bond 1983) were selected for use and are described below. The physical characteristics of each habitat at each sampling period determined the gear types that could be used. However, for each gear type, use was standardized across habitats to facilitate comparisons. Table 1 summarizes the gear use for all habitats and both sampling periods.

25. Electroshocker. Electroshocking was conducted with a commercially built, 230-V, pulsed DC, boat-mounted boom shocker. Individual electroshocking samples (runs) were of 6-min duration and covered approximately 1000 linear feet in all habitats except ACH, where electroshocking runs were only 500 ft. Five electroshocking samples were collected from each habitat or dike field subhabitat.

26. Sampling runs along the river side of the dike field middle bars, and along natural banks and revetted banks, were made in a downstream direction, parallel to the bank or bar. Within dike field pools, runs were made along the dikes, along the shoreline, and through the

middle. Secondary channels were sampled along both banks and through the middle. Electroshocking runs in the abandoned channel were made in the relatively open center area.

27. Gill nets. Gill nets were 150 ft long by 8 ft deep and consisted of six 25-ft-long by 8-ft-deep panels. Each panel contained nylon multifilament mesh of a single size, with mesh sizes changing in 0.5-in. increments from 1 in. at one end of the net to 3.5 in. at the other. Gill nets were used in the secondary channels, the abandoned channel, and dike field pools. Nets were set perpendicular to the shoreline in the secondary channels and dike field pools, but in the abandoned channel nets were set at a 45-deg angle to the bank so that they could be completely deployed in this narrow habitat.

28. Gill nets were set for two consecutive 24-hr periods, giving a total effort of four net-days in each habitat or dike field subhabitat at each sampling period, with one exception. During June, strong currents in most areas of the dike field pools limited sampling to the setting of a single net in a single pool of each dike field; therefore, at this time only two net-days of effort could be made in each dike field.

29. Hoop nets. Five hoop nets were set in each habitat or dike field subhabitat during each sampling period. Nets were 3 ft in diameter, with seven fiberglass hoops and 1-in.-square-mesh tarred nylon netting throughout. Hoop nets were set in at least 6 ft of water near each lettered marker in the natural and revetted bank habitats, in the abandoned channel habitat, and along the dike field middle bars. In secondary channels and dike field pools, hoop nets were set at randomly selected stations along the lettered marker transect lines. Hoop nets were always set with the opening facing downstream; nets were held open with bridle ropes if necessary when no current was present.

30. Nets were set for two consecutive 24-hr periods, giving a total effort of 10 net-days per habitat or dike field subhabitat per sampling period. Nets lost or twisted, or otherwise judged to be fishing improperly, were reset for an additional 24-hr period.

31. Seine. A 15-ft-long by 4-ft-deep minnow seine with 1/8-in. delta mesh was used to sample shallow areas in the dike fields and

secondary channels. Five 50-ft hauls were made in each secondary channel and in both pools of Case Bar dike field (DFB) at each sampling period. The middle bar of DFB could not be seined at either sampling period. Strong flows during June restricted seining in Estes Place dike field (DFA) to the middle bar and Pool 2; during September, Pool 1 could also be seined.

Macroinvertebrates

32. Ideally, field investigations should use a single sampling gear and a single sampling design. The diverse habitat conditions encountered within this study precluded such a program, however. Conditions ranged from slack currents and predominantly silt-sand substrates during low discharges to moderate to strong currents and predominantly sand substrates during high discharge periods. Therefore, for this study the decision was made to use the gear and sampling design best suited to the conditions which existed during each sampling effort and in each habitat.

33. Grab samplers. Two grab samplers, a Shipek and a petite ponar, were used to sample macroinvertebrates; two sampling designs, stratified random and systematic, were used to ensure that sampling was complete. The two dike fields (DFA and DFB) were sampled utilizing a stratified random design due to the patchy distribution of the various sediment types in June. Substrates were sampled with benthic grab samplers, and the substrate of each dike field was mapped before benthic samples were taken. Points within each habitat were then selected for benthic sampling, with substrates presumed to be more productive being sampled proportionally more often than their occurrence in the habitat.

34. A systematic transect sampling scheme was utilized in all of the other habitats, as substrate type was relatively uniform. A ponar grab was used in low-current, soft, depositional substrates (secondary channels and dike field pools), while a Shipek grab was used in sampling areas having moderate to high currents and a sand and gravel or clay substrate (natural banks). In studies performed on the Lower Mississippi River, Bingham et al. (1982) concluded that the Shipek grab was more suitable than either the large or petite ponar for use in high-energy

environments, and that the petite ponar was most suitable for comparative studies in depositional substrates.

35. Rock baskets. The macroinvertebrate fauna of the dike and revetment structures was sampled using rock-filled, rectangular wire baskets, 25.4 cm × 25.4 cm × 30.4 cm. These sturdy, inexpensive containers are constructed of steel-weld wire and are open at the top. The baskets have sufficient spacing between adjacent support wires (5.1 cm) to allow for unimpeded movement of aquatic macroinvertebrates among the rock-filled container, the surrounding rock substrate, and the water. Open spacing of the support structure, coupled with the use of representative (well-sorted) substrate obtained directly from the surface of the dike or revetment (above the waterline), provided representative conditions for colonizing macroinvertebrates. The samplers were filled with similar sizes and numbers of rocks to minimize variations in total density estimates among samplers.

36. On 22 April 1982, 48 rock basket samplers were placed on revetted banks and dike structures. On each of the two revetted banks, rock baskets were deployed along four equally spaced transects positioned along and perpendicular to the bank. Three samplers were placed along each transect beginning near the shore and working into the river, giving a total of 12 samplers along each revetted bank. The baskets were tied together in trotline fashion and anchored to a permanent shoreline structure with 1/8-in., vinyl-coated aircraft cable. At least 15 ft of excess cable was used between baskets to prevent disturbance to nearby samplers during the retrieval process.

37. Rock basket samplers were placed on the dike structures in a similar manner. Three transects were established on the most upstream dike in each dike field, and six baskets (two on each transect) were placed on both the upstream and downstream sides of the dike. Baskets were anchored to pilings in the dikes with the same type of cable used on the revetments. Baskets were retrieved by hand on 27-29 July, using the anchor cables to slowly raise the baskets to the bow of a johnboat, where they were placed in metal tubs. Baskets were 2-6 ft deep at time of retrieval and had been underwater continuously since placement. After

scrubbing to remove macroinvertebrates, rock baskets were reset at the same locations and retrieved on 15-16 September.

38. Sample processing. Grab samples were sieved in the field using a US Standard 35-mesh screen (openings = 500 μ). Rocks removed from the rock basket samplers were cleaned using nylon brushes, and the material removed from the rocks was sieved through the same standard screen. All samples were preserved in the field in 10-percent formalin. In the laboratory, samples were stained with Rose Bengal, hand sorted at 3X magnification, grouped into major taxonomic categories, and transferred to a 70-percent ethanol solution. Oligochaetes were transferred to a lactophenol clearing solution at least 5 days prior to identification. Chironomids were prepared for identification using the mounting procedure of Beckett and Lewis (1982). Macroinvertebrates were identified to the lowest possible taxon.

Statistical Analyses

Fish

39. Mean numerical catch per unit of effort (C/f) and mean total weight of fish per unit of effort (C/y) were calculated for each habitat or dike field subhabitat and each gear type during each sampling period. A one-way analysis of variance (ANOVA) by gear type was used to determine whether significant catch differences existed among habitats or subhabitats during either sampling period. Data were transformed as log (X + 1) prior to analysis, as is generally appropriate for species abundances (Green 1979). Subsequent to the ANOVA, Duncan's New Multiple Range Test was used to examine the pattern of the differences.

40. Condition factors (K) were calculated for individual fish of the following species: gizzard shad; channel, blue, and flathead catfish; bluegill; freshwater drum; and white crappie. The K value is an index relating the length and weight of individual fish, which is based on the reasonable assumption that, for any given length, heavier fish are in better physical condition than lighter fish. This index has been used extensively in fishery work and is suitable both for comparing individual

fish within a species and for indicating differences related to sex, season, or place of capture (Ricker 1975). Differences in fish condition among habitats or subhabitats were examined using a one-way ANOVA and Duncan's New Multiple Range Test. Only fish collected with comparable gear types were used in making comparisons among habitats.

41. Habitats were compared using two similarity coefficients. The first, here termed "coefficient of community (CC)," was developed by Dice (1945); it is among the most suitable indices of its type (Hubalek 1982). The CC is a linear function that can range from 0.0 (no species in common, fish communities completely dissimilar) to 1.0 (all species in common, fish communities identical); it is therefore interpretable in a straightforward, direct manner. The second index, termed "percentage similarity," evaluates the faunal resemblance of two areas on the basis of the relative percentages of their various species. This index, like the CC, is linear and ranges from 0.0 to 1.0. It is mathematically identical to 1.0 minus the value of the Bray-Curtis dissimilarity index (Boesch 1977), but is easier to understand and discuss than the latter index. Sample calculations for both similarity coefficients can be found in Whittaker (1975).

Macroinvertebrates

42. Macroinvertebrate composition of the habitats was expressed in terms of the species present and their relative numbers. In order to compare habitats sampled with the ponar and Shipek grab samplers, which collect different-sized "bites" of the substrate, counts were converted to numbers/square metre. Densities of invertebrates on the rock basket samplers could not be converted to a similar standard because the surface area of the rocks was not known. The macroinvertebrate faunas of habitats sampled with this technique were compared only on the basis of the number of taxa and their relative abundances per basket.

43. Coefficient of community values based on grab samples only were calculated for pairs of habitats as described above for fish. The CC values were subsequently used in a similarity diagram (Whittaker 1975, Beckett 1978) to summarize the habitat relationships.

PART IV: RESULTS

Physicochemical

44. The physicochemical data indicated that relatively small differences existed among habitats at any given time. In contrast, the character of the system could change markedly over short periods of time. Particularly large differences existed between the June and September sampling efforts. Physicochemical characteristics of the river at each sampling date are summarized in the following discussion.

Temperature

45. On 10 and 20 June, water temperatures were 24-25° C at all depths in all habitats, with one exception. Late afternoon temperatures in Case Bar secondary channel (TCC) were 1-2° C higher on 20 June.

46. Early morning water temperatures on 15 September were 27-28° C from the surface to a depth of 10 ft in all habitats. The coolest temperatures were recorded in the dike field scour holes, where the bottom temperature at 30 ft was 26° C. By late afternoon the surface temperatures of all habitats had increased to 28-29° C, but bottom temperatures were unchanged. The passage of a cold front on 21 September caused water temperatures to drop considerably and to become uniform at all depths. Early morning temperatures on 23 September were 22-24° C in all habitats; by late afternoon, surface temperatures had risen by 1-2° C, whereas bottom temperatures were unchanged.

Dissolved oxygen concentration

47. On 10 June, dissolved oxygen (DO) concentrations were 7.0-7.5 mg/ℓ in both early morning and late afternoon. No differences were apparent among the habitats. The DO concentrations were 7.5-8.5 mg/ℓ at both times on 20 June. Concentrations were similar at all depths on both dates.

48. On the morning of 15 September, DO stratification was observed. At this time, concentrations were 6.4-7.4 mg/ℓ at the surface, 5.0-5.8 mg/ℓ at 10 ft, 4.3-5.8 mg/ℓ at 13-15 ft, and as low as 2.2 mg/ℓ in the dike field scour holes. No consistent differences among habitats

for similar depths were apparent. By late afternoon on 15 September, surface concentrations had risen to 8.3 mg/ℓ in the four bank habitats and to 10.0-13.7 mg/ℓ in the dike fields and secondary channels. A gradient of decreasing DO concentration with depth existed, with minimum bottom readings of 5.7 mg/ℓ as deep as 30 ft; however, this gradient was not as extreme as in previous samples.

49. The cooling and mixing caused by the cold front noted above briefly disrupted DO stratification in all habitats. Concentrations shortly after passage of the front ranged from 6.6-7.6 mg/ℓ at the surface to 6.7 mg/ℓ at 30 ft. However, by late afternoon of the same day, DO stratification was again apparent, with concentrations ranging from 8.7-10 mg/ℓ at the surface to 6.3 mg/ℓ in the deepest dike field scour holes.

Conductivity

50. Conductivity readings were much lower during June than during September. On 10 June, conductivities in all habitats ranged from 500-550 μmho/cm in the early morning and from 460-470 μmho/cm in late afternoon. On 20 June, conductivities were 570-600 μmho/cm at both times. No depth or habitat differences were apparent.

51. Conductivity values ranged from 750-820 μmho/cm early on 15 September and from 730-770 μmho/cm in late afternoon. Samples taken on 23 September showed higher conductivities, 830-890 μmho/cm early in the day and 795-850 μmho/cm later in the afternoon. In all instances, conductivities were lowest in Case Bar secondary channel (TCC) and similar in other habitats.

pH

52. On 10 June, pH values ranged from 7.2-7.6 across all habitats. The 20 June values were more variable and generally higher, from 6.8-8.2, but showed no consistent differences among habitats or depths.

53. The 15 September pH values were 6.5-7.0 in early morning but increased to 7.0-8.2 by late afternoon. At this time, Estes Place dike field (DFA) consistently had the lowest values; pH in all other habitats was approximately equal. Following the 21 September cold front, pH ranged from 7.8-8.3 in all habitats in both morning and afternoon.

Current speed

54. Current speeds were markedly different in the study area between June and September. During June, discharges were moderately high and at least some current was present in nearly every habitat (Figure 3).

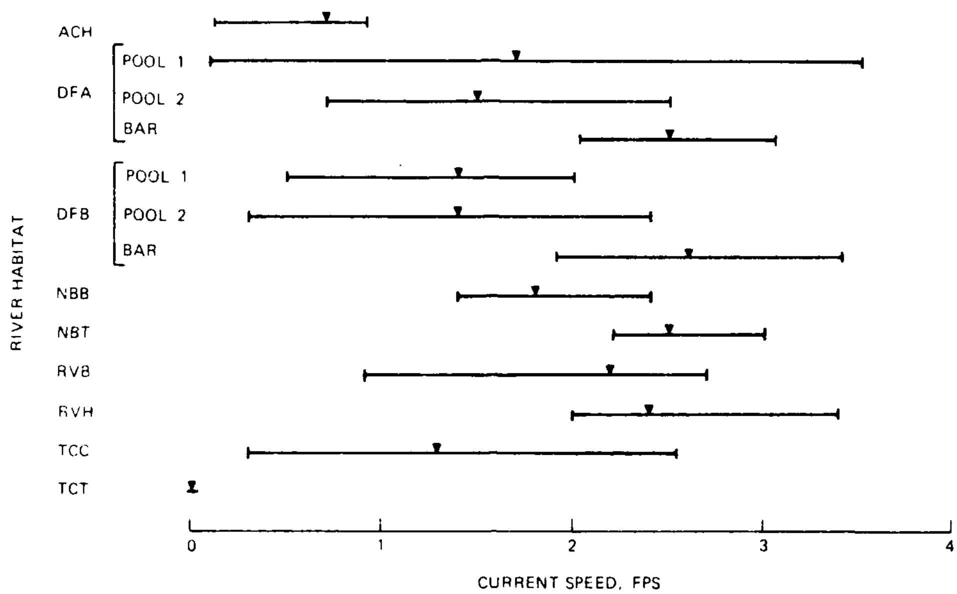

Figure 3. Current speeds of study habitats in Pool 5 of the McClellan-Kerr Arkansas River Navigation System during 10-20 June 1982. Horizontal lines indicate the range of current speeds; triangles indicate means. (Habitat acronyms are explained in Figure 1)

Currents within the pools of DFA ranged from 0.0-3.2 fps; in the pools of DFB, currents ranged from 0.3-2.4 fps. Current speeds in both dike fields were greater through the midportions than along the shoreline, and they were generally higher at the surface than near the bottom. Middle bar (channel edge) current speeds were 2.0-3.0 fps in DFA and 1.8-3.5 fps in DFB.

55. Current velocities were high along both natural and revetted banks during June. Revetted banks did not show significantly higher currents speeds than natural banks. Rather, the upstream habitat of each type had higher current speeds than the downstream habitat. Fletchers Cutoff Natural Bank (NBT) and Harris Bend Revetment (RVH) had current speeds of 2.2-3.1 fps and 2.0-3.4 fps, respectively. Currents at Brodie

Bend Natural Bank (NBB) ranged from 1.4-2.4 fps, and those at Brodie Bend Revetment (RVB) were 1.0-2.7 fps.

56. Case Bar secondary channel (TCC) had current speeds ranging from 0.3-2.5 fps. Tar Camp Crossing secondary channel (TCT) had essentially no current, except in the immediate vicinity of the lower end where some eddy currents were present. Harris Bayou abandoned channel (ACH) had a fairly uniform current of 0.7 fps through the middle. Near the banks, the current was slow to slack.

57. Discharge during September ranged from 1000-8700 cfs, only 1-6 percent of that during the June sampling effort. At those discharges there is no detectable current, even in the navigation channel.

Fish Collections

58. A total of 16,630 fish representing 48 species were collected during the two sampling periods, with 2,916 fish in 32 species being taken in June and 13,714 fish in 42 species being captured in September. Common and scientific names of fish collected in this study are given in Table 2 and follow the most recent American Fisheries Society listing (Robins et al. 1980). In most instances, common names are used throughout this report.

59. Eleven species collectively comprised over 90 percent of the fish collected during the study. These species and their relative abundances (as percentages of the population) were: inland silverside (38.1), red and blacktail shiners combined (28.5), gizzard shad (10.9), channel catfish (4.3), bullhead minnow (4.1), freshwater drum (2.1), blue catfish (1.7), white crappie (1.5), bluegill (1.4), and river carpsucker (1.1).

60. The red and blacktail shiners were combined because in the study area they exhibit a high degree of hybridization and apparent introgression. A preliminary analysis of a small number of fish from this red-blacktail shiner complex, based on the work of Sorensen (1981), strongly suggests that fish of hybrid origin make up more than 60 percent of this complex. However, without a detailed morphological study, which is beyond the scope of this report, the actual extent of introgression

cannot be ascertained. In addition, there are both practical and theoretical problems in unambiguously identifying fish from natural hybrid swarms (Neff and Smith 1979). In this report, individuals of this complex have been assigned to the morphologically "closer" of the two parental species. The reader should be aware that when these species are mentioned in the report, we may actually be referring to a hybrid swarm.

Catch-per-effort

61. June. The overall ANOVA F-tests indicated highly significant differences for both catch-per-effort indices for electroshocker and gill nets (Table 3). The multiple range tests showed a general pattern for number of fish per 24-hr gill net set (C/f) of secondary channels > dike fields > abandoned channel (Figure 4). The pattern for weight of fish (C/y) was less distinct, but similar (Figure 5). The secondary channels (TCC and TCT) also ranked highest, along with one revetment (RVB), in the number of fish collected by electroshocker (Figure 4); however, all habitats showed very low electroshocker catches, the highest mean being fewer than 10 fish per run. In terms of weight, RVB and one secondary channel (TCC) again ranked considerably above all other habitats (Figure 5), whereas the other secondary channel (TCT) was not as high relative to other habitats as it was for numbers.

62. Although no statistically significant differences were indicated for hoop net mean numbers (Table 3), TCC and the Estes Place dike field (DFA) middle bar catches were much higher than those at other habitats (Figure 4). The mean weight values were more variable (Figure 5), but the TCC and DFA middle bar catches were again high. Other habitats with relatively high weight catches were DFA Pool 1, Case Bar dike field (DFB) Pool 2, Fletchers Cutoff natural bank (NBT), and Harris Bend revetment (RVH).

63. Numbers of fish collected by seine indicated only marginal differences among habitats (Table 3), and seine weight catches indicated no significant differences.

64. September. Highly significant F-ratios for numbers (C/f) were observed for gill nets and hoop nets in September (Table 3), and the F-ratios for electroshocker and seine also suggested differences.

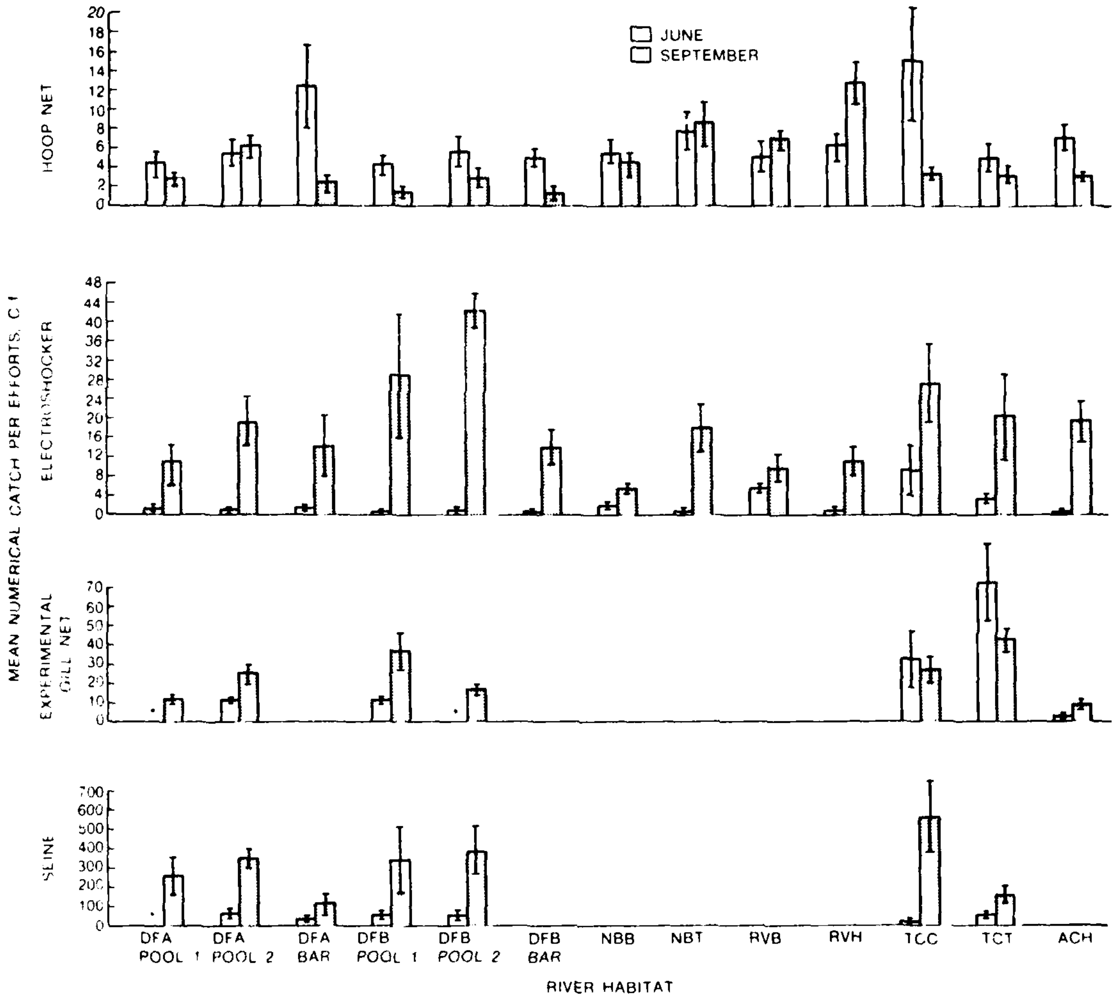

Figure 4. Mean numerical catch per efforts in study habitats in Pool 5 of the McClellan-Kerr Arkansas River Navigation System during June and September 1982. Vertical lines indicate one standard error about the means. Asterisks denote habitats in which gear could not be used. (Habitat acronyms are defined in Figure 1)

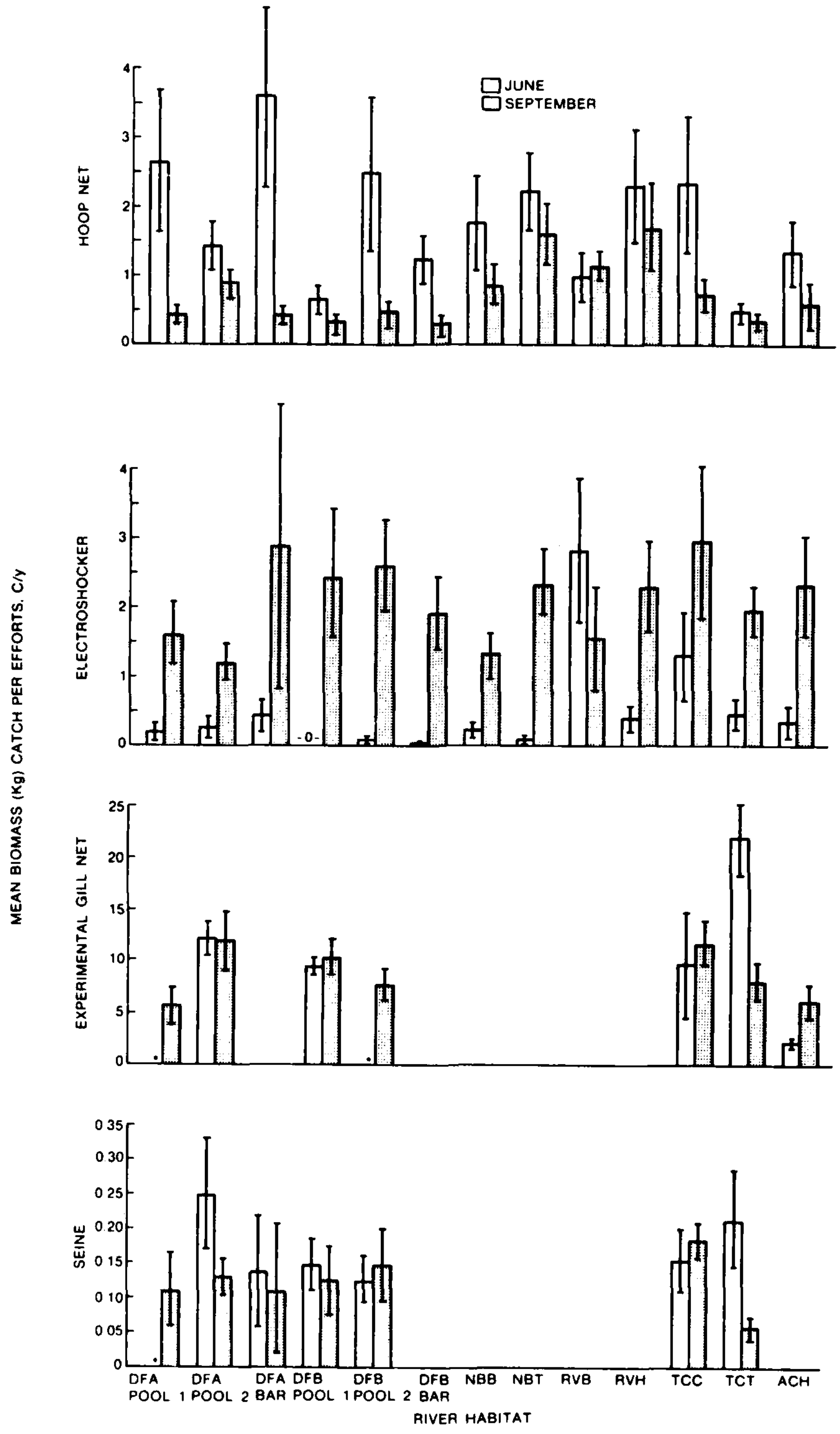

Figure 5. Mean biomass catch per efforts in study habitats in Pool 5 of the McClellan-Kerr Arkansas River Navigation System during June and September 1982. Vertical lines indicate one standard error about the means. Asterisks denote habitats in which gear could not be used. (Habitat acronyms are defined in Figure 1)

Patterns of variation in gill net C/f were similar to those found in June. However, the mean numbers caught in gill nets increased significantly in the dike field pools over those recorded in June, while numbers decreased in the secondary channels (Figure 4). The numerical gill net catch in the abandoned channel (ACH) remained low. Hoop net mean numerical catch was comparatively high only in the four bank habitats (Figure 4) and in DFA Pool 2. Hoop net catch was actually as high or higher in these habitats during September, when there was no current, than during June, when a strong current existed nearly everywhere.

65. Electroshocking C/f was highest in the DFB pools and in TCC (Figure 4), but it was not significantly higher than in several other habitats. Natural and revetted banks and the dike field middle bars showed generally low electroshocker catches. Electroshocker catches in almost all habitats were significantly greater in September than in June. Seine numerical catches were high in one secondary channel (TCC), low in the other secondary channel (TCT) and the DFA middle bar, and intermediate elsewhere (Figure 4). As with electroshocking, the seine catch was considerably greater in September than in June.

66. Only hoop nets indicated significant differences in weight catches (C/y) among habitats (Table 3). Habitats that showed the highest numbers for hoop nets (bank habitats and DFA Pool 2) also had the highest weight values. Hoop net catch by weight declined considerably in all habitats except one revetment (RVB) from June to September.

Species composition

67. Dike field pool habitat. June hoop net and electroshocker samples from the four dike field pools were dominated by catfishes and freshwater drum (Table 4), with these species accounting for 87.3-100 percent of the fish collected by these two gears. Channel catfish, flathead catfish, and freshwater drum were captured primarily in hoop nets, while most blue catfish were collected by electroshocking. Despite the fact that these species comprised most of the catch in these two gears, there were differences among the four pools. Blue catfish numbers were relatively high only in Estes Place dike field (DFA) Pool 2, while channel catfish were abundant in three of the four dike field pools.

Freshwater drum were more abundant in DFA Pools, especially Pool 1, than in DFB pools. Flathead catfish were common only in one pool of each dike field, DFA Pool 1 and DFB Pool 2.

68. June gill net and seine collections documented the presence of 11 species in DFA pools and 19 species in DFB pools which were not captured by hoop nets or the electroshocker (Table 4). Many of these species were small, and they would be expected to be taken only by seine. Some larger species such as highfin carpsucker, gars, and river carpsucker were either collected only in gill nets or were collected most frequently in them. The inability to either seine or to set gill nets in DFA Pool 1 during June undoubtedly contributed to the smaller number of species being collected overall from DFA pools than from DFB pools.

69. Percentage similarity of the dike field pools (Figure 6) ranged from low to moderately high during June, reflecting the differences in relative abundances noted above. Because many of the same species of fish were captured in each pool, the community similarity index was high for all comparisons (Figure 7).

70. Both the number of species and the number of individuals collected by hoop nets and electroshocker were much higher in September than in June (Table 5). Species collected by these two gears also differed greatly between the two sampling periods. Gizzard shad was the dominant species collected in electroshocker samples in September, whereas it was uncommon in any gear during June. Hoop net catches in September were dominated by white crappie, bluegill, and other centrarchids, in contrast to June when catfishes and freshwater drum comprised most of the catch. In fact, in September, few catfishes were collected in hoop nets in any habitat. Gill net catches showed that channel and blue catfishes were still present in the dike field pool habitat (Table 5). Total catches of these two species (all gears combined) in the dike field pool habitat were lower in September than in June. However, it is not known whether this represents a real difference or is attributable to a decreased efficiency of hoop nets for capturing catfishes in standing water. Gill net catches suggested that channel and blue catfishes might actually have been more common in dike field pools in September. However, this may

SEPTEMBER \ JUNE	DFA POOL 1	DFA POOL 2	DFA BAR	DFB POOL 1	DFB POOL 2	DFB BAR	TCC	TCT	ACH	NBB	NBT	RVB	RVH
DFA POOL 1		56.0	33.3	38.7	69.0	42.3	67.8	36.3	72.1	74.8	61.2	68.1	57.2
DFA POOL 2	83.0 / 72.1		44.7 / 56.7	63.6 / 63.5	59.4 / 62.3	49.3	67.0 / 38.5	52.6 / 57.4	68.3 / 60.3	59.9	61.5	70.3	57.3
DFA BAR	74.8 / 70.0	69.6 / 85.0		73.4 / 58.1	57.5 / 57.5	80.0	32.0 / 40.3	23.8 / 39.5	42.0	49.4	65.1	36.3	48.1
DFB POOL 1	72.0 / 75.0	70.4 / 80.0	77.9 / 88.1		66.3 / 80.1	84.3	49.5 / 34.1	38.1 / 40.4	55.5 / 64.0	57.7	74.0	56.4	48.1
DFB POOL 2	71.0 / 56.4	71.4 / 80.0	71.0 / 78.8	90.7 / 78.7		72.1	43.9 / 34.6	29.9 / 34.1	62.2	87.4	83.2	64.5	68.5
DFB BAR	73.3	75.2	80.6	85.6	86.7		33.8	25.3	52.5	63.5	79.8	50.1	55.3
TCC	65.4 / 76.9	66.9 / 77.3	71.3 / 65.0	90.6 / 85.9	92.0 / 70.8	82.9		51.6 / 57.9	76.1 / 61.6	50.1	51.1	65.9	43.7
TCT	71.0 / 49.3	73.4 / 73.0	64.8 / 70.4	61.7 / 76.7	60.9 / 77.4	65.9	56.3 / 71.3		36.1 / 57.5	27.6	29.3	48.9	35.2
ACH	80.2 / 79.3	83.7 / 82.2	77.4	85.8 / 71.5	77.0 / 70.3	81.1	73.3 / 72.1	73.4 / 74.6		68.2	71.0	69.9	57.2
NBB	60.9	61.0	42.5	38.8	41.0	45.9	35.1	59.9	54.6		81.3	73.0	68.6
NBT	71.6	67.1	69.6	63.0	58.3	64.0	57.4	76.8	66.2	57.2		65.2	65.2
RVB	56.4	55.5	38.5	33.3	36.3	41.0	30.4	54.3	46.6	80.4	55.7		62.9
RVH	50.4	44.3	36.5	33.2	32.3	38.3	28.0	50.7	41.6	69.1	55.2	74.4	

Figure 6. Percentage similarity of fish communities of study habitats in Pool 5 of McClellan-Kerr Arkansas River Navigation System. Single values and values in the upper-left half of boxes are similarities based only on electroshocker and hoop net collections; similarity values in lower-right half of boxes are based on all comparable gears, including gill nets, seines, or both. (Habitat acronyms are defined in Figure 1)

SEPTEMBER \ JUNE	DFA POOL 1	DFA POOL 2	DFA BAR	DFB POOL 1	DFB POOL 2	DFB BAR	TCC	TCT	ACH	NBB	NBT	RVB	RVH
DFA POOL 1		87.5	93.3	72.7	92.3	66.7	85.7	82.4	80.0	71.4	85.7	70.0	87.5
DFA POOL 2	50.0 / 76.4		82.4 / 70.3	61.5 / 74.4	80.0 / 82.1	57.1	75.0 / 80.0	84.2 / 81.8	82.4 / 69.6	62.5	75.0	63.6	77.7
DFA BAR	80.0 / 76.9	61.5 / 77.3		66.7 / 62.9	85.7 / 75.0	46.2	80.0 / 72.7	77.7 / 82.4	87.5	66.7	93.3	66.7	82.4
DFB POOL 1	73.7 / 79.2	72.0 / 75.5	85.7 / 84.2		80.0 / 76.9	88.9	72.7 / 69.8	57.1 / 76.6	66.7 / 90.9	72.7	72.7	47.1	61.5
DFB POOL 2	44.4 / 70.8	58.3 / 79.2	50.0 / 72.2	52.6 / 82.6		72.7	92.3 / 78.8	75.0 / 88.2	85.7	83.3	92.3	63.2	80.0
DFB BAR	60.0	61.5	72.7	76.2	60.0		66.7	53.3	61.5	66.7	66.7	44.4	71.4
TCC	50.0 / 71.7	73.3 / 82.8	69.2 / 72.7	64.0 / 82.4	61.5 / 90.2	69.2		82.4 / 82.6	80.0 / 81.8	66.7	85.7	70.0	87.5
TCT	52.1 / 62.7	75.9 / 75.0	64.0 / 69.8	66.7 / 73.5	60.9 / 77.6	72.0	69.0 / 77.8		77.7 / 75.9	58.8	70.6	78.3	84.2
ACH	58.3 / 64.7	58.3 / 75.0	61.5	64.0 / 70.6	58.3 / 68.6	61.5	73.3 / 84.2	75.9 / 77.8		66.7	93.3	66.7	70.6
NBB	60.0	69.2	63.6	57.1	70.0	72.7	69.2	72.0	69.2		71.4	70.0	62.5
NBT	72.0	71.0	74.1	69.2	64.0	81.5	77.4	66.7	71.0	74.1		70.0	75.0
RVB	57.0	66.7	60.9	45.5	57.1	69.5	59.3	61.5	51.9	69.6	71.4		72.7
RVH	66.7	72.7	75.9	64.3	66.7	69.0	72.7	62.5	72.7	69.0	88.2	73.3	

Figure 7. Coefficient of community (similarity) of fish communities of study habitats in Pool 5 of the McClellan-Kerr Arkansas River Navigation System. Single values and values in the upper-left half of boxes are similarities based only on electroshocker and hoop net collections; similarity values in lower-right half of boxes are based on all comparable gears, including gill nets, seines, or both. (Habitat acronyms are defined in Figure 1)

also have been due to a difference in gear efficiency, as gill nets fish most effectively in standing water.

71. Flathead catfish and freshwater drum were less common in September samples (the above gear efficiency considerations may apply), while longnose gar, shortnose gar, and river carpsucker were more common. Flathead catfish, in particular, showed a sharp decline between sampling dates (40 versus 3). The number of fish collected by seine from the dike field pools in September was several times greater than during June, but the number of species collected was lower. Inland silverside, red shiner, blacktail shiner, and bullhead minnow comprised most of the catch, while brook silverside, river shiner, and silverband shiner were moderately common in occasional seine hauls (Table 5).

72. Fish communities of all four pool habitats were very similar in September (Figures 6 and 7). Pools within a dike field displayed somewhat greater similarity to each other than to pools of the other dike field, but the overall differences were small. Slightly greater numbers of species were collected from Estes Place (DFA) pools (25, Pool 1; 30, Pool 2) than from the Case Bar (DFB) pools (23 each); however, all the additional species were uncommon, and thus contributed little to percentage similarity differences. A few species did show differences among pools. Most skipjack herring, for example, were collected from DFB Pool 1, and all quillback were captured in DFA Pool 2. Silverband shiner, emerald shiner, and gizzard shad were more numerous in DFB pools.

73. Middle bar habitat. June electroshocking and hoop net catches were very similar in terms of abundance at both middle bars (Figure 6). The coefficient of community, however (Figure 7), was low for one of the few times in the study, undoubtedly due to the low number of species collected (Table 4). Channel catfish comprised over 70 percent of the catch along each bar, and blue and flathead catfish were also common. Gizzard shad and river carpsucker were taken in limited numbers along the Estes Place (DFA) bar. Freshwater drum, although captured in this habitat, were taken in very low numbers. During June, hoop nets collected most of the fish along both bars; electroshocking catch-per-effort was negligible in both areas. One major difference between the two bar

habitats was that the hoop net catch-per-effort was nearly three times as great along the DFA bar as along the DFB bar.

74. Further comparison of the two middle bar habitats was not possible, as seining could be accomplished only along the DFA bar. Ten species were collected by seining in this area, eight of which were taken only with this gear (Table 4). Most commonly collected were inland silverside, red shiner, blacktail shiner, bullhead minnow, and juvenile river carpsucker. This was the only habitat in which juvenile river carpsucker were captured. It is not likely that many of these small species would have been collected along the DFB bar during June, when current speeds were consistently above 2 fps, as these species generally prefer somewhat quieter areas.

75. In contrast to June, September electroshocking and hoop net catches were nearly equal in the two middle bar habitats, with the DFA catch declining by about 30 percent and the DFB catch increasing by nearly 50 percent. The number of species collected in each area was equal, and much higher than in June (Table 5). At this time the electroshocker, rather than the hoop nets, captured the majority of the fish. The middle bar habitat in September was dominated by adult gizzard shad. In addition, channel catfish, white crappie, striped bass, and freshwater drum were moderately common along DFA bar, and white crappie and striped bass were the second and third most common species collected along the DFB bar. Although the faunas of these two areas were much different than during June, they again showed a high degree of similarity (Figures 6 and 7).

76. Nine additional species were collected along DFA bar by seining, all unique to that gear (Table 5). Inland silverside, red shiner, and blacktail shiner comprised over 96 percent of the individuals. Physical conditions along DFB bar in September (the slower currents) appeared to be more favorable for these species than in June, and many of them may have been collected in September if seining had been possible.

77. Natural and revetted bank habitats. Both the electroshocker and hoop nets were employed in the four bank habitat sites during June, but hoop nets had much higher catches (Figure 4). Similar numbers of

fish were collected from each of the habitats (Table 4), but the two revetted banks, RVB and RVH, yielded more species. Channel catfish, flathead catfish, and freshwater drum collectively comprised at least 59.8 percent in each bank habitat. Blue catfish were abundant only at Brodie Bend revetment (RVB), and the river carpsucker was common only at Harris Bend revetment (RVH). White bass, striped bass, bluegill, black crappie, and shorthead redhorse were collected along revetments but not along natural banks, although except for white bass these species were rare. No species was unique to the natural bank habitat. Both percentage similarity and coefficient of community indices indicated moderate to high similarity among these four sites (Figures 6 and 7) with the natural banks forming a more similar pair than the revetted banks.

78. The fish populations of the natural and revetted banks during September were considerably different from those of June (Table 5). Electroshocker catch increased significantly, and both electroshocker and hoop nets contributed equally to the collections. The overall numbers of fish and fish species were much higher during September, and the relative abundances of the species were quite different. Numbers of catfishes and freshwater drum collected declined markedly overall, although they were present along most banks, and in a few instances they were still common (i.e., channel catfish at Fletchers Cutoff natural bank (NBT); flathead catfish at both revetted banks). Due to the lack of any current, a "standing water" fish community consisting predominantly of gizzard shad, bluegill, longear sunfish, white and black crappie, and white bass dominated the bank habitats. Bluegill, longear sunfish, and white bass numbers, in particular, were as high or higher in the bank habitats than elsewhere. The four Ωερομισ (bluegill-like sunfishes) species were all more numerous on the revetted banks, as were flathead catfish. Gizzard shad and channel catfish were most numerous at NBT.

79. Although seining was not possible along the bank habitats, schools of small fishes were often seen. Observations of their behavior, size, and general appearance indicated that these included juvenile sunfishes, adult and juvenile minnows, adult and juvenile silversides, and possibly juvenile gizzard shad.

80. Three of the four bank habitats (RVB, RVH, and NBB) had very similar fish communities during September (Figures 6 and 7) and as a group were somewhat distinct from all other habitats, including NBT. The only major difference among the former three habitats was the relatively low total catch of fish at NBB.

81. Secondary channel habitat. Very similar species were collected in the two secondary channels (Figure 6), and these were similar to those collected with comparable gears in other habitats (Table 4; Figure 7). However, the abundance of particular species was often quite different between the secondary channels and the other habitats, and also between the two secondary channels. These habitats were physically dissimilar during June, when no current existed in Tar Camp Crossing secondary channel (TCT) and a moderate current existed in Case Bar secondary channel (TCC) (Figure 3). Gars, river carpsucker, channel catfish, inland silverside, adult bluegill, white crappie, and striped bass were all more abundant in TCT than in TCC, while blue catfish and freshwater drum showed the opposite abundance pattern. These differences were reflected in the moderate percentage similarity of these habitats in June (Figure 6).

82. Catches in seines and by electroshocker greatly increased in the secondary channels during September, while catch in hoop nets and gill nets declined (Figure 4). Overall numbers of fish were considerably higher, primarily due to the great increase in seine catch of inland silverside, blacktail and red shiners, and bullhead minnow, and an increase in gizzard shad taken by the electroshocker (compare Tables 4 and 5). Channel catfish, blue catfish, and freshwater drum abundance declined. The number of species captured in this habitat also increased over June, from 20 to 28 in TCC and from 24 to 26 in TCT. The overall catch and number of species in TCC exceeded that of TCT in September (Table 5). The community similarity (Figure 7) between these two habitats declined somewhat, but the percentage similarity increased (Figure 6). Blacktail shiner, red shiner, inland silverside, bullhead minnow, gizzard shad, and river carpsucker were all more abundant in TCC, while threadfin shad, channel catfish, bluegill, and longear sunfish

were more numerous in TCT. Longnose and shortnose gar were captured only in TCC, while spotted gar were more common in TCT.

83. Abandoned channel habitat. Channel, blue, and flathead catfishes, along with freshwater drum, comprised most of the catch in the abandoned channel (ACH) (Table 4) in June. Most fish were captured in hoop nets; however, shortnose gar, spotted gar, goldeye, and white bass, although uncommon, were taken in gill nets.

84. The number of species of fish collected in ACH increased from 12 to 19 during September (Table 5), and the number of individuals taken nearly doubled (161 versus 84). The number of fish collected in hoop nets declined precipitously, while the catch in gill nets and with the electroshocker increased. The September catch was composed mainly of gizzard shad, white crappie, river carpsucker, spotted gar, and channel catfish. All three species of catfishes, along with freshwater drum, declined greatly in numbers compared to June. Spotted gar was the only species of gar taken here during September and, along with bowfin, reached its greatest abundance in this habitat.

Habitat comparisons

85. Species composition. The almost invariably high coefficient of community values (Figure 7) indicated that the fish species of the study pool were relatively ubiquitous during both sampling periods. Most of the even moderately abundant species (Tables 4 and 5) were collected in nearly every habitat where the appropriate gears were employed. The percentage similarity index (Figure 6), however, indicated that the habitats were relatively distinct in terms of the species' relative abundances during June, when the physical differences among the habitats were greatest.

86. Based on only electroshocker and hoop net samples, which were collected in all habitats, the middle bar and Case Bar dike field (DFB) pool habitats formed a rather distinctive group dominated by channel catfish. Within the group, DFB Pool 2 was least dominated by channel catfish and had a relatively greater percentage of flathead catfish and freshwater drum. In this respect, DFB Pool 2 somewhat resembled Estes Place dike field (DFA) Pool 1 and the four bank habitats.

87. Natural and revetted banks formed a second set of similar habitats (Table 4 and Figure 6). Differences in the proportions of a single species in each bank habitat, river carpsucker at Harris Bend revetment (RVH), channel catfish at Fletchers Cutoff natural bank (NBT), flathead catfish at Brodie Bend natural bank (NBB), and blue catfish at Brodie Bend revetment (RVB), caused these four locations to show affinity in similarity to slightly differing sets of the other habitats. Brodie Bend natural bank (NBB), for example, showed the highest similarity to DFA Pool 1 and DFB Pool 2, in which freshwater drum, flathead catfish, and channel catfish comprised most of the catch. Fletchers Cutoff natural bank (NBT) showed relatively high similarity to many "nonbank" habitats, while RVH showed somewhat low similarities to most of these same locations. Brodie Bend revetment (RVB) was, likewise, similar to some "nonbank" habitats and dissimilar to others.

88. The similarity values shown in Figures 6 and 7 which involve bank-nonbank habitat comparisons should probably be considered overestimates of the true similarities, as they are based only on electroshocker and hoop net samples. Habitats having appreciable slack-water areas also included minnows, silversides, and sunfishes in their fish communities. Due to the rigorous physical nature of the bank habitats during June, many of these species were probably not present or were present only in very low numbers along the banks, and thus the actual similarities of bank habitats to nonbank habitats may be much lower than indicated. The same consideration applies to the middle bar habitats.

89. The secondary channels, TCC and TCT, were unique habitats. High percentages of gizzard shad in gill net and electroshocker samples, and the relatively low abundance of minnows in seine samples, differentiated them from most other habitats during June. In particular, TCT did not show more than a moderate degree of similarity to any other habitat during June, and percentage similarity estimates based on comparable gears indicated that TCC was similar only to one dike field pool (DFA Pool 1), one revetted bank (RVB), and the abandoned channel (ACH). However, for the same reasons noted above, these may be overestimates of the true similarity. The swift currents along RVB, and in most parts of DFA

Pool 1, probably would have precluded the presence of most of the small species collected by seine in TCC.

90. Length-frequency. During June, channel catfish less than 200 mm total length (TL) were abundant only in Tar Camp Crossing secondary channel (TCT), and to a lesser extent in TCC (Figure 8). In all other habitats the size distribution of this species was restricted to larger fish, from 200-550 mm TL. In TCT an abundance peak centered about 300 mm TL was also apparent which was not found in the other habitats. The size distribution of channel catfish collected in September (Figure 9) was similar to that in June. Smaller fish were again common only in TCT, even though gill nets, which appeared to be most effective for collecting small fish, were used in all except the bank habitats.

91. The size range of blue catfish collected from Case Bar secondary channel (TCC) in June was much greater than from most other habitats (Figure 10). The catch of individuals of this species less than 200 mm TL was also greatest here, although a few were collected in other habitats, primarily Estes Place dike field (DFA) Pool 2 and TCT. In contrast to channel catfish, most of the smaller blue catfish were captured with the electroshocker instead of the gill nets. Very few (n=49) blue catfish were collected in September; all were larger individuals, and they showed no preferences among habitats.

92. During June, gizzard shad were collected in sufficient numbers to analyze length-frequency only in TCT, TCC, and DFA Pool 2. No difference in shad size distribution was indicated at this time, as fish from 175-275 mm TL dominated the catch. Examination of gizzard shad length-frequency plots for September, however, suggested some differences among the habitats (Figure 11). Fish less than 150 mm TL, most likely young-of-year fish, were commonly captured in the secondary and abandoned channels (TCC, TCT, and ACH) and in Pool 2 of both dike fields. Revetted and natural bank habitats, the middle bar habitat, and Pool 1 of each dike field had almost exclusively larger fish. Because no current was present in any habitat at this time, and because the electroshocker which captured most of the shad was used in all habitats, it is assumed that the differences were real. What caused the observed

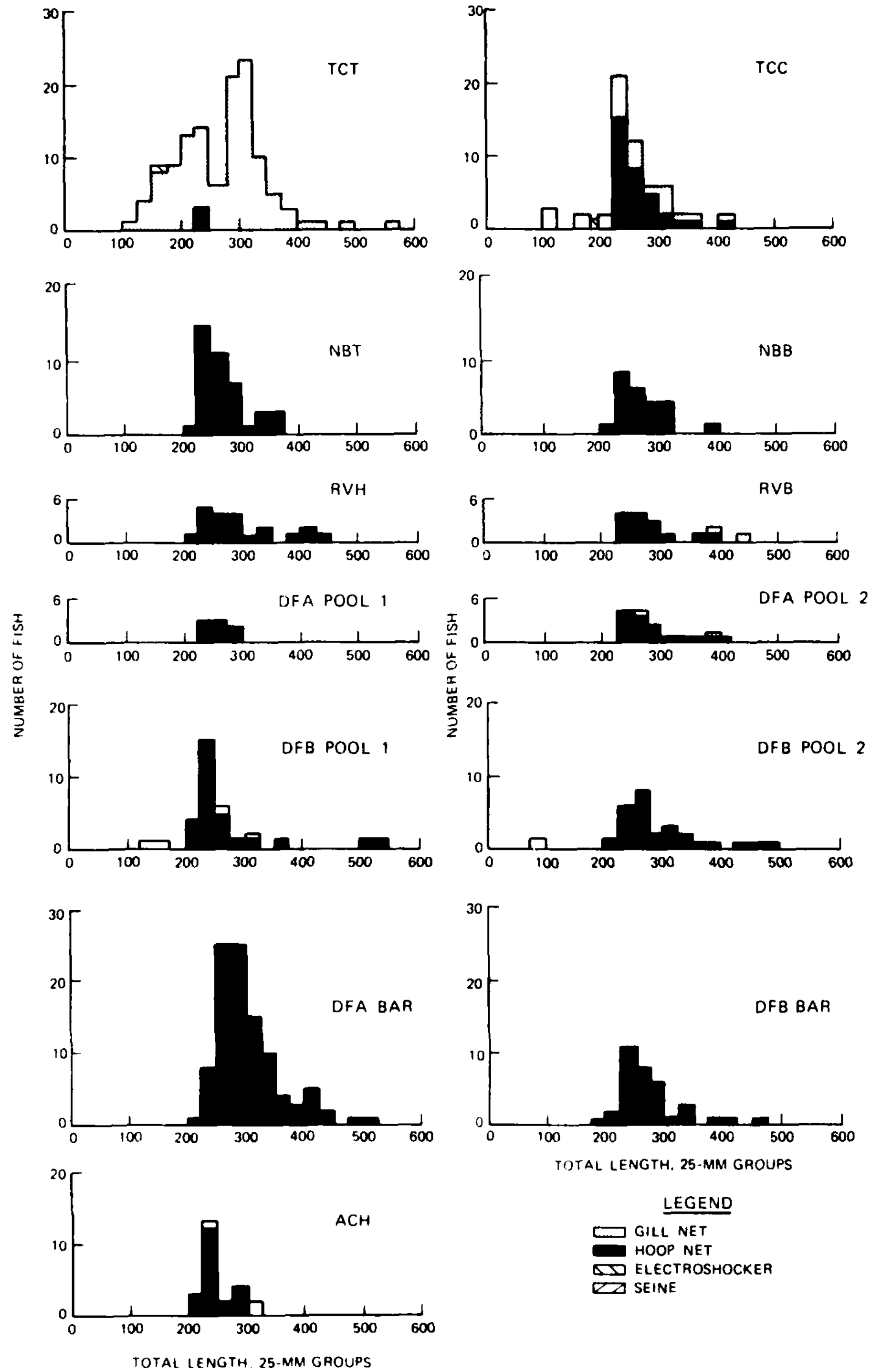

Figure 8. Length-frequency of channel catfish collected during June 1982 from Pool 5 of the McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

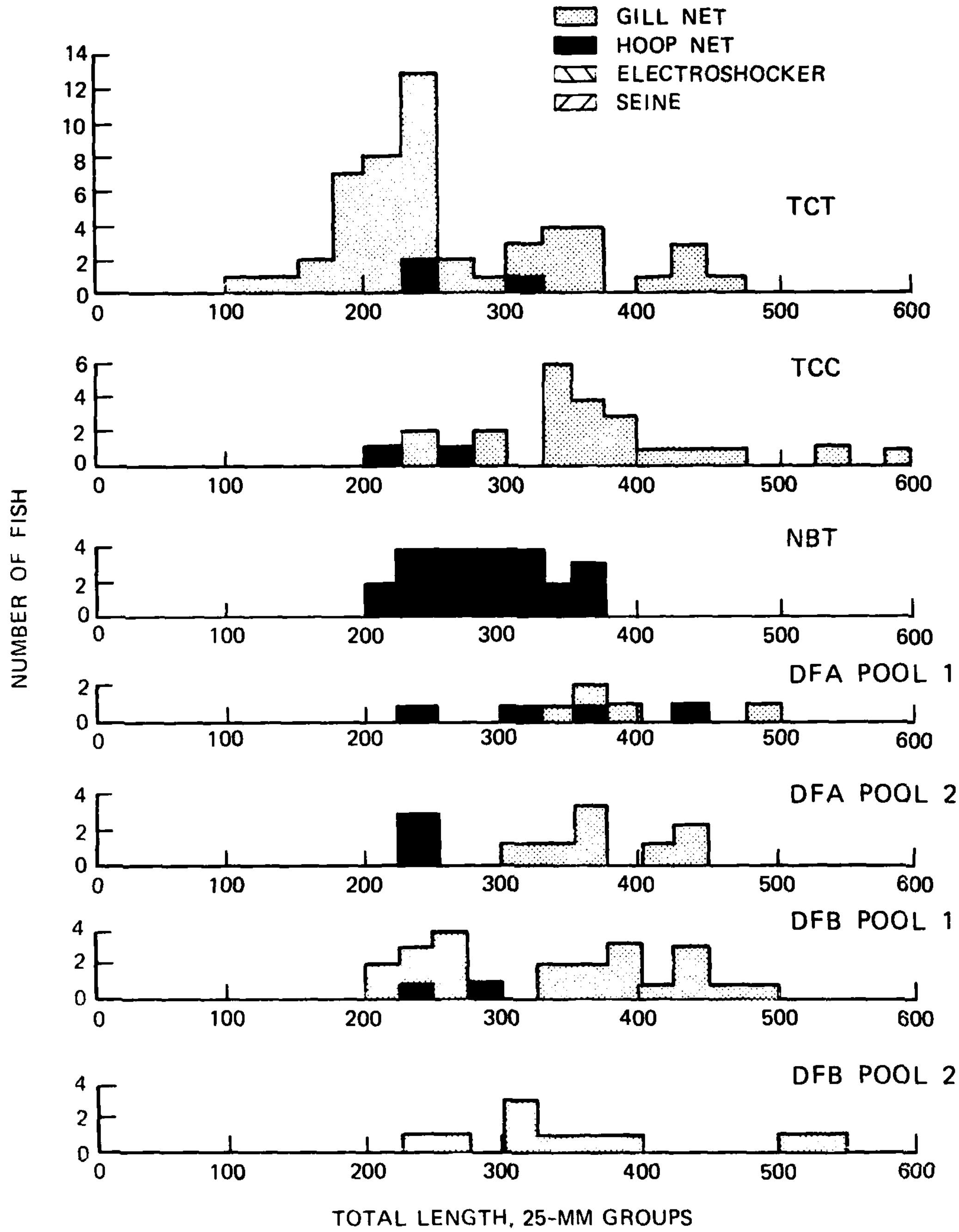

Figure 9. Length-frequency of channel catfish collected during September 1982 from the McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

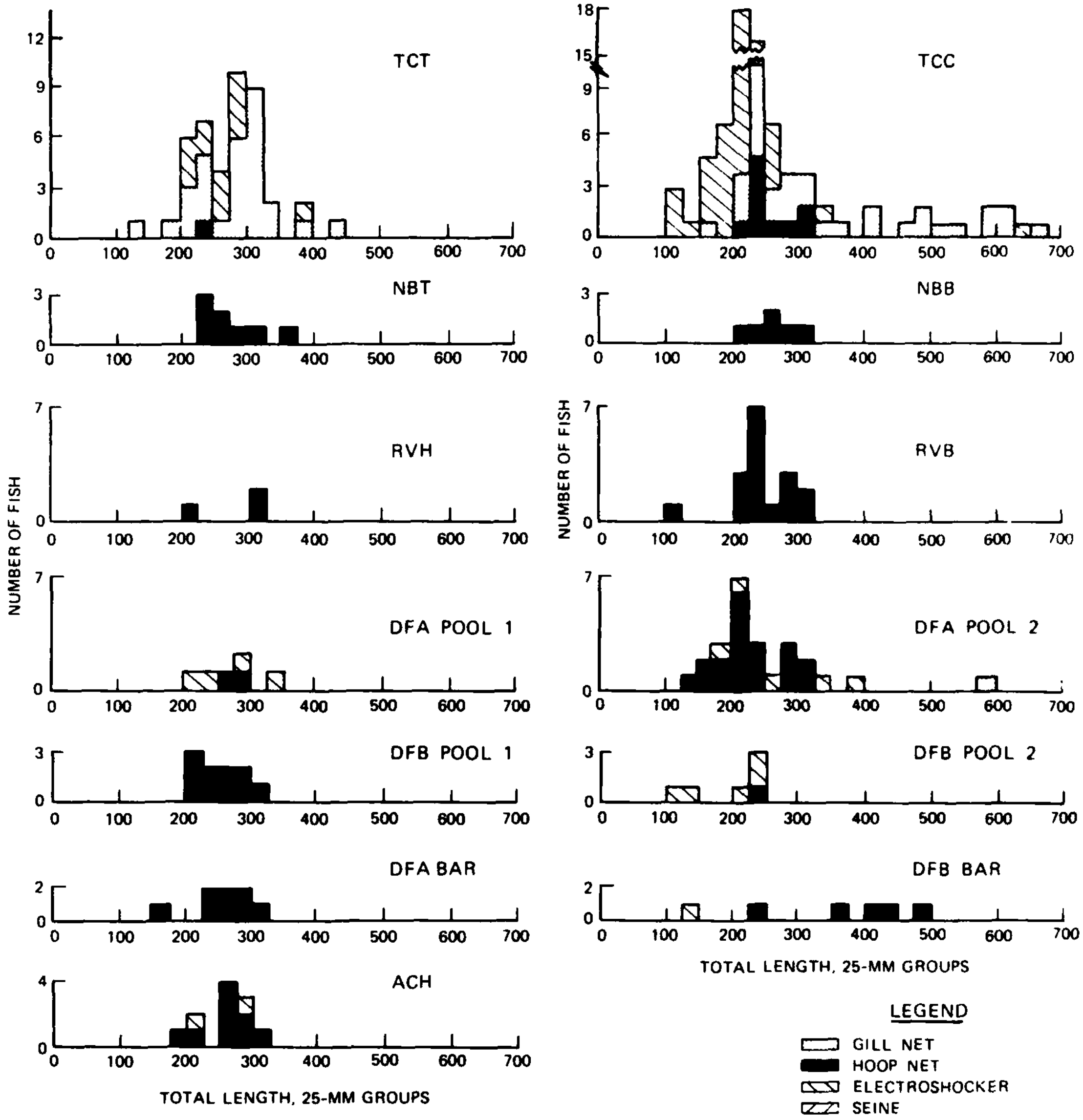

Figure 10. Length-frequency of blue catfish collected during June 1982 from Pool 5 of the McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

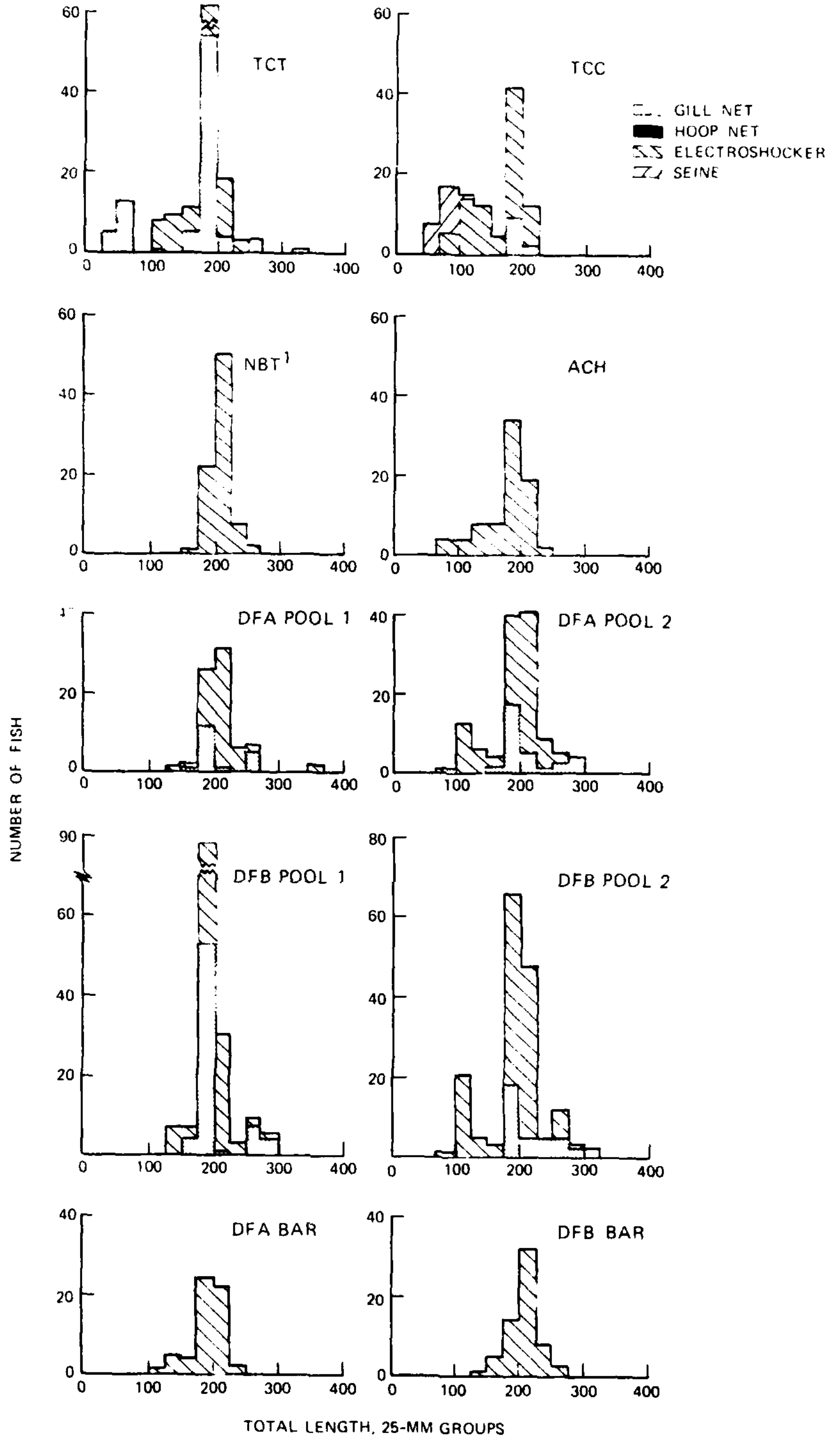

Figure 11. Length-frequency of gizzard shad collected during September 1982 from McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

size distribution of gizzard shad is not known, however.

93. A wide size range of freshwater drum (75-525 mm TL) was collected during June, although most were in the range from 150-350 mm TL. The majority of the freshwater drum were collected from three habitats, TCC, TCT, ACH. In these three habitats, the size distributions of this species showed some differences. In the abandoned channel (ACH) and one secondary channel (TCC), this species had abundance peaks in the 150-250 mm TL range. In TCC there was a second abundance peak from 250-350 mm TL that was less apparent in ACH. In Tar Camp Crossing secondary channel (TCT), the majority of the drum were smaller, ranging mostly from 100-200 mm TL; very few larger freshwater drum were collected in this habitat. During September, drum were again most common in the secondary channels, and to a much lesser extent along the banks. Fish lengths ranged from 150-300 mm TL and were similar in all these habitats.

94. Flathead catfish were not collected at either sampling period in numbers sufficient to confidently assess length-frequency differences among habitats. However, the data did suggest that somewhat larger flathead catfish inhabited the natural banks as compared to the revetted banks. Slightly larger fish were also collected from two dike field pools, DFA Pool 1 and DFB Pool 2.

95. White crappie and bluegill showed no differences among the habitats during either sampling period, except for the obvious difference that young-of-year fish were collected wherever seining was possible. Adult fish from 150-300 mm TL (white crappie) and 100-175 mm TL (bluegill) were commonly collected with the other gear types, especially hoop nets, during September.

96. Condition factors. Mean condition factors (K) of white crappie collected during June varied considerably across the six habitats in which adults of this species were captured (Figure 12). Although the low number of individuals collected in many habitats precluded demonstration of statistical differences, fish collected from the only quiet-water habitat available at this time had the highest mean K value. Four of the six habitats showed higher K values during September than during June. However, the only two habitats which had relatively large sample sizes

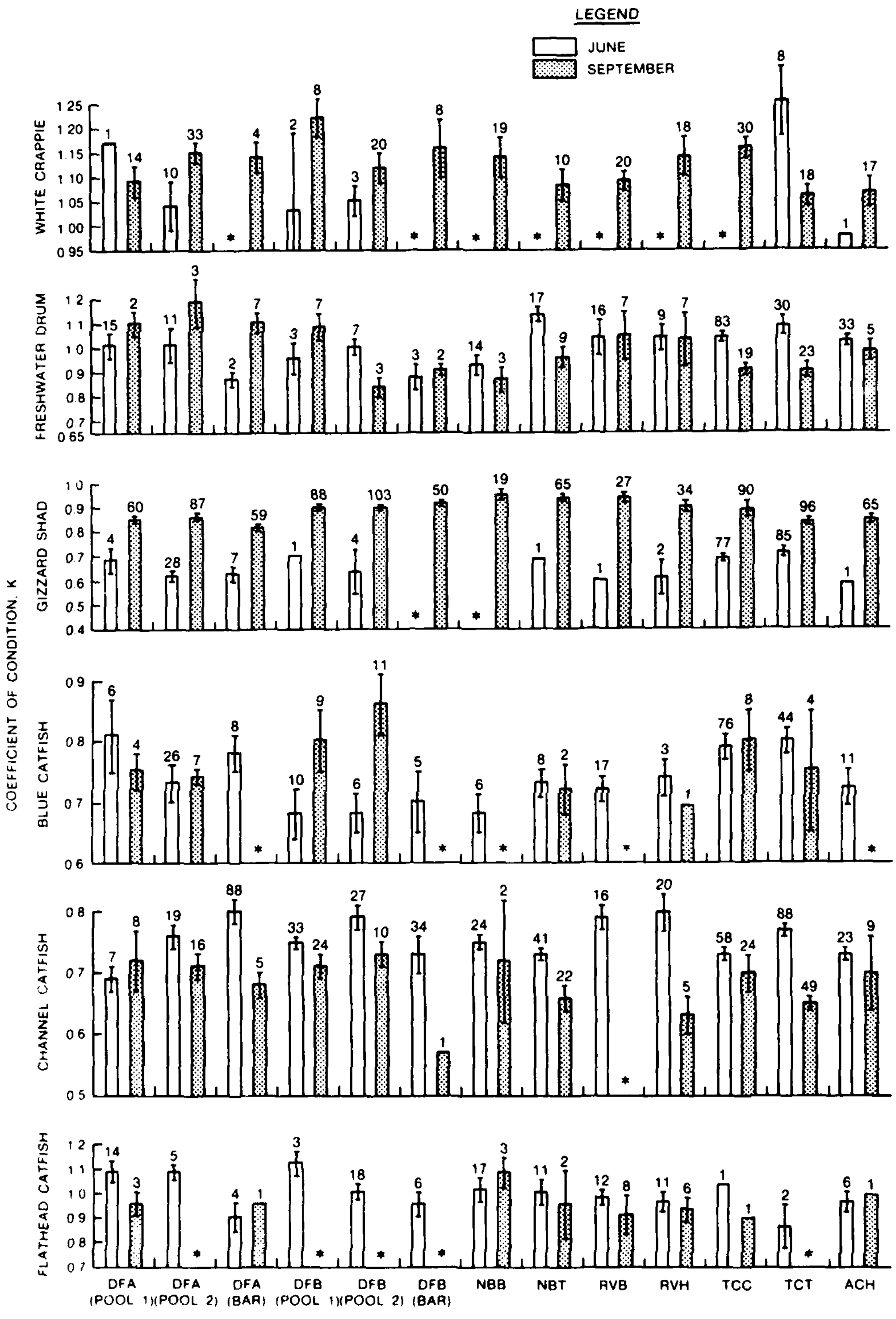

Figure 12. Condition factors of selected fish species from the McClellan-Kerr Arkansas River Navigation System. Vertical lines indicate one standard error about the means. Numbers indicate sample sizes. Asterisks indicate no fish collected in the habitat. (Habitat acronyms are defined in Figure 1)

during both months gave contradictory results. The K values for DFA Pool 2 white crappie were significantly higher in September ($t=2.83$, $d.f.=41$, $P < 0.005$) than in June, while in TCT condition factors showed a significant drop at this time ($t=3.59$, $d.f.=24$, $P < 0.005$). Because white crappie spawn during early spring, the differences in condition could not be attributed to the presence of eggs in female fish.

97. The relationship of freshwater drum condition factors between June and September was variable, with some habitats showing increases in September and some showing decreases. Overall mean K values (all habitats combined) did not differ significantly between months (June $\bar{x} = 1.03$; September $\bar{x} = 1.00$). However, the three habitats which had relatively high samples sizes for both months all showed large, significant declines in K values from June to September: Fletchers Cutoff natural bank (NBT) ($t=3.13$, $d.f.=24$, $P < 0.005$); Case Bar secondary channel (TCC) ($t=2.66$, $d.f.=100$, $P < 0.005$); and Tar Camp Crossing secondary channel (TCT) ($t=3.53$, $d.f.=51$, $P < 0.001$). Like white crappie, freshwater drum spawn in early spring, so that the generally higher June K values could not be attributed to high ovarian weights of female fish.

98. Condition factors for gizzard shad showed little variability among habitats during either month (Figure 12). Overall mean K values were significantly higher ($t=3.17$, $d.f.=1048$, $P < 0.001$) in September ($\bar{x} = 0.88$) than in June ($\bar{x} = 0.69$).

99. Mean K values for channel catfish collected during June and September did not vary greatly among habitats, ranging from 0.69-0.80 in June and from 0.57-0.73 in September. Between months, though, there was a small but consistent difference (overall June $\bar{x} = 0.76$; overall September $\bar{x} = 0.69$). The presence of ripe eggs in female channel catfish collected in June indicated that our sampling coincided with the spawning period. Thus, it is likely that the weight of gonadal tissue, which may account for 5-10 percent of total body weight, was the primary reason for the overall higher June condition factors.

100. Mean blue catfish K values showed no pattern that could be attributed to habitat characteristics. In fact, K values among habitats showed the greatest divergence in September (Figure 12), when the

habitats appeared to be least different physically. Unlike channel catfish, blue catfish showed no overall tendency for K values to be consistently greater in either month.

101. As with most other species, flathead catfish showed no consistent differences among habitats or months (Figure 12). Overall mean K values were not significantly different in June ($\bar{x} = 1.01$) than in September ($\bar{x} = 0.96$).

Macroinvertebrate Collections

Epilithic fauna (July)

102. In July, during the retrieval of rock basket samplers, current velocities ranged from 1.0-2.5 fps at the upstream end of the study pool to 0-1.5 fps at the lower end of the study pool. Habitats located near the upstream end, Harris Bend revetment (RVH) and Estes Place dike field (DFA), were exposed to moderate current while habitats located further downstream, Case Bar dike field (DFB) and Brodie Bend revetment (RVB), were exposed to little or no current.

103. Revetted banks. A total of 5824 organisms representing 37 taxa (Table 6) were collected at RVH in July. The average sample density was 485.3 organisms per rock basket. Current velocities ranged from 1.0-2.5 fps along this stretch of revetted bank. The hydropsychid caddisflies, *Hydropsyche orris, Potomyia flava*, and *Cheumatopsyche* sp., were the dominant macroinvertebrates collected, comprising 43.7 percent of the total numbers (Figure 13). Also of numerical importance were the polycentropodid caddisflies, *Cyrnellus fraternus* and *Neureclipsis crepuscularis*, comprising 35.0 percent of the total. The Chironomidae were the next most abundant group, representing 9.0 percent of the total numbers. The chironomid fauna was numerically dominated by *Dicrotendipes nervosus* (Type I) (see Simpson and Bode 1980), *Dicrotendipes neomodestus*, and *Ablabesmyia parajanta*. The amphipod, *Corophium lacustre*, was common to all samples but did not occur in large numbers.

104. In July a total of 10,368 organisms representing 43 taxa (Table 6) were collected from RVB, where the average sample density was

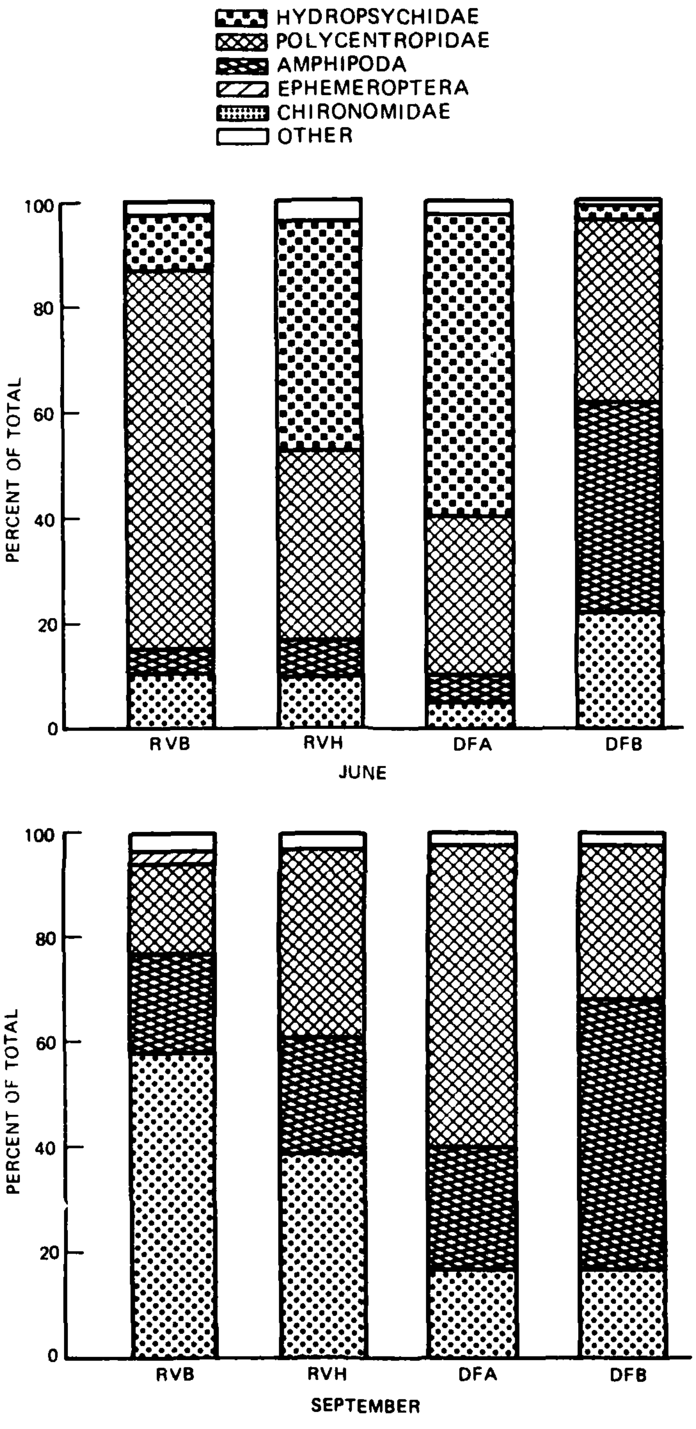

Figure 13. Community composition of dominant benthic macroinvertebrates colonizing dike and revetment structures in Pool 5 of the McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

864.0 organisms per rock basket. Current velocities at RVB ranged from undetectable to 1.0 fps. Macroinvertebrate community composition was similar to that of RVH; however, a shift in dominance was detected. The polycentropodid caddisflies, *Cyrnellus fraternus* and *Neureclipsis crepuscularis*, were the dominant macroinvertebrates, comprising 72.1 percent of the total sample. The Chironomidae were the next most abundant group, followed by the hydropsychid caddisfly, *Hydropsyche orris*, representing 10.7 and 10.3 percent, respectively, of the total numbers. The Chironomidae were numerically dominated by *Dicrotendipes nervosus, Dicrotendipes neomodestus, Ablabesmyia parajanta*, and *Glyptotendipes* sp. The amphipod, *Corophium lacustre*, appeared in relatively low numbers.

105. Dike structures. A total of 6256 organisms representing 19 taxa were collected from DFA in July (Table 6). The average sample density at DFA was 1042.6 organisms per rock basket, with current velocities ranging from 1-2.5 fps. The fauna closely resembled that of RVH, with the hydropsychid caddisflies *Hydropsyche orris* and *Cheumatopsyche* sp. comprising 57.1 percent of the total sample; the polycentropodid caddisflies *Cyrnellus fraternus* and *Neureclipsis crepuscularis* comprising 31 percent; and the Chironomidae comprising 5.0 percent. The Chironomidae were numerically dominated by *Polypedilum illinoense, Tanytarsus* sp., and *Dicrotendipes nervosus* (Type I). The amphipod *Corophium lacustre* was again ubiquitous but appeared in relatively low numbers.

106. A total of 543 organisms representing 19 taxa (Table 6) were collected in July at DFB, with an average sample density of 271.5 organisms per rock basket. Current velocities ranged from undetectable to 1.0 fps. Although community composition at this location was similar to that of RVB, a shift in the relative abundance of the dominant macroinvertebrate groups collected was apparent. The amphipod *Corophium lacustre* was the dominant macroinvertebrate collected, accounting for 39.7 percent of the total numbers (Figure 13). Next in order of numerical importance were the polycentropodid caddisfly *Cyrnellus fraternus* and the Chironomidae, representing 34.9 and 21.9 percent, respectively. The Chironomidae were numerically dominated by *Glyptotendipes* sp. and *Dicrotendipes neomodestus*.

Epilithic fauna (September)

107. When rock basket samplers were retrieved in September, physical conditions encountered within the study area were markedly different from those of July. For example, there was no detectable current in September in any of the habitats being investigated, and water level was lower.

108. Revetted banks. A total of 16,990 organisms representing 37 taxa (Table 6) were collected at RVH. The average sample density was 1415 organisms per rock basket. The Chironomidae were the dominant macroinvertebrate group collected, representing 39.3 percent of the total numbers. Next in abundance were the polycentropodid caddisfly *Cyrnellus fraternus* and the amphipod *Corophium lacustre*, representing 36.3 and 22.0 percent, respectively (Figure 13). The Chironomidae were numerically dominated by *Dicrotendipes nervosus* (Type I), *Dicrotendipes neomodestus*, and *Ablabesmyia parajanta*.

109. At RVB a total of 7790 organisms representing 34 taxa (Table 6) were collected; the average sample density was 649.1 organisms per rock basket. The Chironomidae were again the dominant macroinvertebrate group collected, representing 58.3 percent of the total sample (Figure 13). The amphipod *Corophium lacustre* and the polycentropodid caddisfly *Cyrnellus fraternus* represented 18.7 and 17.4 percent, respectively, of the total. The Chironomidae were numerically dominated by *Dicrotendipes neomodestus*, *Tanytarsus* sp., and *Ablabesmyia parajanta*.

110. Dike structures. A total of 10,600 organisms representing 26 taxa (Table 6) were collected at DFA, with an average sample density of 1325.0 organisms per rock basket. The polycentropodid caddisfly *Cyrnellus fraternus* was the dominant macroinvertebrate, comprising 57.7 percent of the total numbers (Figure 13). The amphipod *Corophium lacustre* (21.1 percent) and the Chironomidae (17.1 percent) were the second and third most abundant taxa. The Chironomidae were numerically dominated by *Cricotopus* spp., *Dicrotendipes nervosus* (Type I), and *Nanocladius distinctus*.

111. A total of 4798 organisms representing 23 taxa were collected at DFB (Table 6), where the average samply density was 959.6 organisms

per rock basket. The amphipod *Corophium lacustre* was the dominant macroinvertebrate collected, representing 51.2 percent of the total numbers (Figure 13). It was followed in abundance by the polycentropodid caddisfly *Cyrnellus fraternus* and the Chironomidae, representing 30.7 and 17.1 percent, respectively, of the total. The Chironomidae were numerically dominated by *Dicrotendipes nervosus* (Type I), *Glyptotendipes* sp. and *Ablabesmyia parajanta*.

112. The macroinvertebrate community colonizing the revetted banks and dike structures in July was characterized by both lotic- and lentic-adapted organisms and was comprised primarily of Hydropsychidae (Trichoptera), Polycentropodidae (Trichoptera), and Chironomidae (Diptera). Harris Bend revetment and Estes Place dike field (RVH and DFA), located near the upstream end of the study pool, were exposed to a moderate current, while Case Bar dike field and Brodie Bend revetment (DFB and RVB), located near the downstream end, were exposed to little or no current. This physical difference was expressed in the relative abundances of the dominant macroinvertebrate families collected in these two areas. The Hydropsychidae, principally *Hydropsyche orris*, was the dominant macroinvertebrate group collected at RVH and DFA, comprising 43.7 and 57.1 percent, respectively, of the total numbers. Next in order of numerical importance were the polycentropodid caddisflies, principally *Cyrnellus fraternus*, which comprised 35.0 percent and 31.0 percent, respectively, of the total numbers.

113. Community composition at the downstream sites, RVB and DFB, exhibited a shift in dominance as compared to those located upstream (RVH and DFA). The polycentropodid caddisflies comprised 72.1 and 34.9 percent, respectively, of the total sample, while the Hydropsychidae, which was the dominant macroinvertebrate group collected at DFA and RVH, represented only 10.3 and 0.7 percent, respectively. The Chironomidae was the most diverse group collected at each site. *Dicrotendipes nervosus* (Type I), *Dicrotendipes neomodestus*, *Ablabesmyia parajanta*, *Nanocladius distinctus*, and *Glyptotendipes* sp. were numerically important species collected at all sites.

114. A group of special interest that was common to all samples

and was the dominant macroinvertebrate collected at DFB in both July and September was the Amphipoda, specifically *Corophium lacustre*. Two other species of amphipods, *Hyalella azteca* and *Gammarus faciatus*, were collected, but in small numbers. *Corophium lacustre* is common in marine or brackish waters (Wass et al. 1972) and has not previously been record·d from the Arkansas River;* however, it now appears to be very common in the lower Arkansas River.

115. In September there was no detectable current at any of the habitats sampled. The macroinvertebrate fauna collected at this time was composed of lentic species. The Hydropsychidae, the dominant macroinvertebrate group collected in July, accounted for only 1 percent or less of the total numbers in samples collected during September. The dominant macroinvertebrate groups collected in September--Chironomidae, Corophidae, and Polycentropodidae--all exhibited an increase in density in September compared to July, with the exception of the polycentropodids (*Cyrnellus fraternus* and *Neureclipsis crepuscularis*) at RVB where a slight decrease was noted. With the exception of RVB, all habitats showed significant increases in total density in September. The deposition of sediment in some of the rock basket samplers at RVB eliminated potential habitat suitable for colonization.

116. The Chironomidae were the most diverse group of macroinvertebrates collected in September and were numerically dominated by *Dicrotendipes neomodestus*, *Dicrotendipes nervosus* (Type I), *Tanytarsus* sp., and *Ablabesmyia parajanta*. The amphipod *Corophium lacustre*, which occurred in relatively low numbers in most samples collected in July, was one of the dominant species in all habitats sampled in September.

Embenthic fauna

117. In June, flow regimes varied among habitats within the study pool, ranging from slack in small isolated sections of Estes Place dike field (DFA) to 3.0 fps at Fletchers Cutoff natural bank (NBT) (Figure 3). Sediment type in the various habitats ranged from silt-clay in slackwater areas to coarse sand and gravel in areas exhibiting erosional

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* Personal Communication, 7 February 1984, Dr. Richard Heard, Gulf Coast Research Laboratory, Ocean Springs, Miss.

currents. Conversely, in September there was no detectable current in any of the habitats sampled, and substrate type was predominantly mud and fine sand (silt).

118. Dike fields. From the two dike fields, a total of 75 grab samples were collected in June. Sediments were variable within each dike field and ranged from mud and fine sand to coarse sand and gravel. Overall, a total of 1799 organisms were collected representing 58 taxa (Table 7). The average macroinvertebrate sample density for the two dike fields was 569.2 organisms/square metre. It should be noted that, due to the sampling design employed in the dike field habitat (stratified random), more effort was concentrated in the productive substrates, i.e. mud. This resulted in density estimates that are somewhat inflated, since this type substrate was uncommon to this particular habitat type.

119. At Estes Place dike field (DFA), a total of 744 organisms and 50 taxa (Table 7) were collected in June grab samples. The average sample density was 501.4 organisms/square metre (Figure 14). Current velocities ranged from slack to 3.2 fps. Although sediment types varied (unconsolidated muds, mud and fine sand (silt), and coarse sand), coarse sand was the predominant substrate. Oligochaeta, principally Tubificidae, was the dominant group of macroinvertebrates collected, representing 54.3 percent (Figure 15) of the total numbers. Numerically important species within this group were *Branchiura sowerbyi*, *Limnodrilus maumeensis*, and *Limnodrilus hoffmeisteri*. Immature tubificids comprised over 50 percent of the total number of oligochaetes collected, but they could not be identified to the generic level. The Chironomidae (Diptera) were next in order of numerical importance, comprising 30.6 percent of the total numbers, and were represented principally by *Tanypus stellatus*, *Coelotanypus* sp., and *Procladius* sp.

120. A total of 1025 organisms representing 39 taxa (Table 7) were collected in June at Case Bar dike field (DFB), where the average sample density was 637.0 organisms/square metre (Figure 14). Substrates ranged from mud and fine sand (silt) to coarse sand, with coarse sand being the predominant substrate. Oligochaeta (principally Tubificidae) was the dominant group collected, representing 86.4 percent of the total

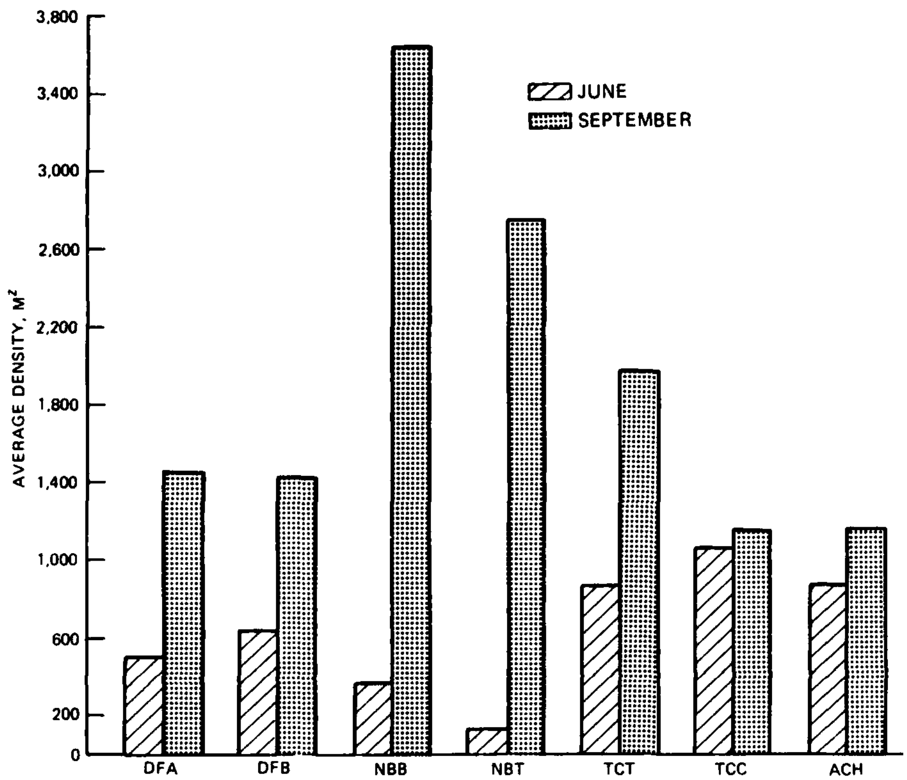

Figure 14. Densities of macroinvertebrates collected from aquatic habitats in the McClellan-Kerr Arkansas River Navigation System during 1982. (Habitat acronyms are defined in Figure 1)

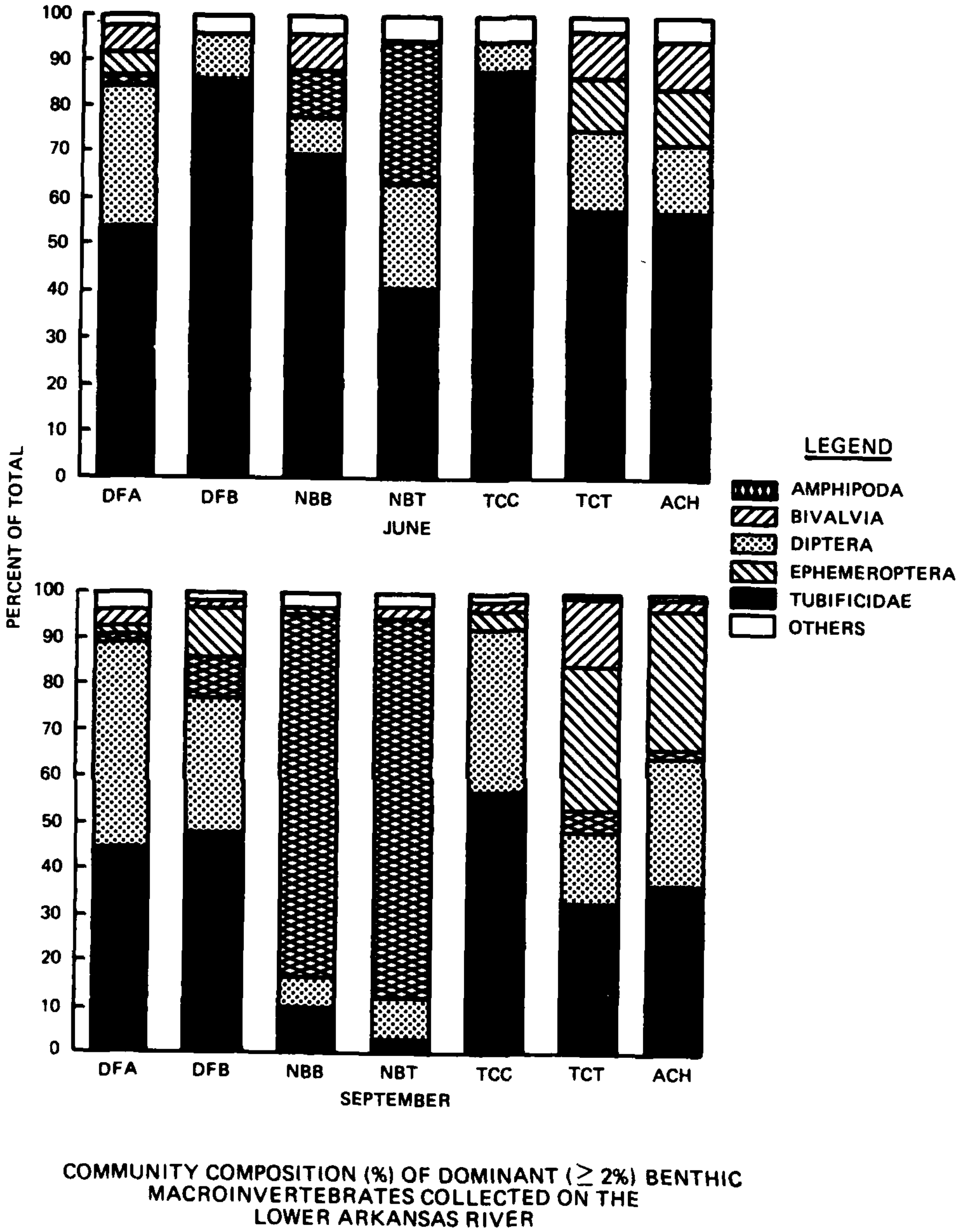

Figure 15. Community composition (%) of dominant (≥2%) benthic macroinvertebrates collected on the lower Arkansas River

numbers. Species of numerical importance within this group were *Limnodrilus maumeensis*, *Limnodrilus hoffmeisteri*, and *Branchiura sowerbyi*. The Chironomidae were next in order of numerical importance, comprising 9.5 percent of the total. This group was represented principally by *Polypedilum illinoense*, *Xenochironomus* sp., and *Coelotanypus* sp.

121. From the two dike fields, DFA and DFB, 80 benthic grab samples were collected in September. Sediment type was predominantly mud and fine sand, with some areas within each habitat exhibiting either a mud or sand substrate. Overall, a total of 1699 organisms representing 62 taxa (Table 8) were collected. The average macroinvertebrate sample density was 1459.4 organisms/square metre.

122. At DFA a total of 1368 organisms were collected representing 53 taxa (Table 8), and the average sample density was 1472.3 organisms/square metre (Figure 14). Two families of Oligochaeta, Tubificidae, and Naididae together comprised 44.8 percent (Figure 15) of the total number of macroinvertebrates and were the dominant groups collected at DFA. The numerically important species representing the tubificid oligochaetes were *Aulodrilus pigueti*, tubificid immatures, *Limnodrilus hoffmeisteri*, and *Limnodrilus maumeensis*, while the Naididae were numerically dominated by *Pristina breviseta* and *Dero digitata*. Second and third in numerical importance were the Chironomidae and the Chaoboridae (Diptera) representing 25.7 and 18.8 percent, of the total, respectively. The Chironomidae were represented principally by *Polypedilum halterale* and *Cryptochironomus* sp., while the Chaoboridae were represented by a single species, *Chaoborus punctipennis*.

123. A total of 1345 organisms, representing 42 taxa (Table 8), were collected from DFB, where the average sample density was 1446.5 organisms/square metre. Oligochaetes, principally Tubificidae, were again the dominant group collected, comprising 45.7 percent of the total numbers (Figure 15). Next in order of importance were the Chironomidae (24.9 percent), the ephemerid mayflies *Hexagenia* spp. (10.4 percent), and the amphipod *Corophium lacustre* (8.6 percent). The chironomid fauna was numerically dominated by *Polypedilum halterale*, *Tanypus stellatus*, and *Chironomus* sp.

124. The total number of taxa increased with a decrease in flow, with 62 taxa collected in September as compared to 58 collected in June. In June, the dike field habitat was characterized by predominantly coarse sand substrates, a wide range of current velocities, and relatively low macroinvertebrate densities. Conversely, in September, substrate type was principally mud and fine sand, there was no detectable current, and relatively high macroinvertebrate densities were noted (Figure 14). The macroinvertebrate assemblage was characterized principally by tubificid oligochaetes and chironomid larvae, in both June and September samples. However, naidid worms, *Aulodrilus pigueti* (Tubificidae); *Chaoborus punctipennis* (Chaoboridae); and ephemerid mayflies, *Hexagenia* spp., were collected in significantly higher numbers in September than June.

125. Natural banks. A total of 28 samples were collected from the two natural banks in June. Sediments were predominantly sand, with isolated areas of silt in areas where eddy currents were present. Clay deposits were rare along both reaches of natural bank; however, clay substrate was collected in a few benthic grabs. A total of only 312 macroinvertebrates were collected, representing 24 taxa (Table 7). The average macroinvertebrate sample density for the two natural banks was 264 organisms/square metre.

126. From Brodie Bend natural bank (NBB), a total of 237 organisms representing 22 taxa were collected in June (Table 7). The average sample density was 387.5 organisms/square metre (Figure 14). Current velocities ranged from 1.4-2.7 fps, and substrate type was principally sand, with isolated areas of silt in areas where eddy currents were present. The Oligochaeta (principally Tubificidae) were the dominant group collected, comprising 70.0 percent of the total numbers (Figure 15). Numerically important species within this group were *Limnodrilus udekemianus* and *Limnodrilus hoffmeisteri*. Immature tubificids comprised over 57 percent of the total sample. Amphipoda, principally *Gammarus fasciatus*, was next in order of numerical importance, comprising 10.9 percent, followed by the pelecypod *Corbicula fluminea* and the Chironomidae, representing 8.4 and 7.5 percent, respectively. The chironomid population was numerically dominated by *Xenochironomus* sp.

127. A total of only 75 organisms representing nine taxa (Table 7) were collected at Fletchers Cutoff natural bank (NBT) in June. The average sample density was 140.5 organisms/square metre (Figure 14). Current velocities were generally higher than at NBB (2.2-3.0 fps), and the substrate was coarse sand along the entire reach of this natural bank. Tubificids were the dominant macroinvertebrate group collected (41.3 percent), with immature tubificids, *Branchiura sowerbyi*, and *Limnodrilus hoffmeisteri* being the numerically important species. Next in order of numerical importance were amphipoda (32.3 percent), principally *Gammarus fasciatus*, and the chironomid *Xenochironomus* sp. (22.6 percent).

128. A total of 30 benthic grab samples were collected from the two natural banks in September. Sediment type varied from mud, to mud and fine sand, to coarse sand. A total of 3975 organisms were collected, representing 36 taxa (Table 8). The average macroinvertebrate sample density was 3209.1 organisms/square metre.

129. At NBB a total of 2276 organisms were collected representing 32 taxa (Table 8). The average sample density at this natural bank was 3674.2 organisms/square metre (Figure 14). Sediment type was predominantly mud and mud-fine sand. The amphipod *Corophium lacustre* was the dominant macroinvertebrate collected, comprising 79.2 percent of the total sample numbers (Figure 15). Next were the Oligochaeta (principally Tubificidae) and the Chironomidae, representing 10.1 and 6.6 percent, respectively. The Tubificidae were represented principally by tubificid immatures, *Brachiura sowerbyi*, and *Limnodrilus udekemianus*, whereas the chironomid fauna was dominated numerically by *Cryptochironomus* sp. and *Xenochironomus* sp.

130. A total of 1699 organisms representing 25 taxa were collected at NBT, where the average sample density was 2744.1 organisms/square metre (Figure 14). Sediment type was principally sand, although a few grab samples contained mud. The amphipod *Corophium lacustre* was again the dominant macroinvertebrate collected, accounting for 83.2 percent of the total numbers (Figure 15). This species was followed in abundance by the Chironomidae and the Tubificidae, representing 8.5 and 3.5 percent, respectively. The chironomid fauna was numerically

dominated by *Cryptochironomus* sp., *Glyptotendipes* sp., and *Xenochironomus* sp., and the tubificid oligochaetes were dominated numerically by immature tubificids and *Limnodrilus maumeensis*.

131. The total number of taxa collected increased with a decrease in flow, with 36 taxa collected in September as compared to 24 taxa collected in June. Natural bank habitat was characterized in June by sandy substrates, high current velocities, and low macroinvertebrate density estimates; in September, substrate type was typically sand and silt, there was no detectable current, and macroinvertebrate densities were relatively high. The macroinvertebrate fauna colonizing the natural banks was comprised primarily of tubificid oligochaetes, chironomid larvae, and amphipods in both June and September. The amphipods, however, which accounted for a total of 43.2 percent of the total sample numbers in June, showed a significant increase in September, accounting for 79.2 and 83.2 percent, respectively, at NBB and NBT. The amphipods not only exhibited a marked numerical increase in density in September but also exhibited an unexplained phenomenon whereby *Gammarus fasciatus*, the dominant amphipod in June, was totally absent from samples collected in September and was replaced by *Corophium lacustre*.

132. Secondary channels. A total of 28 samples were collected in the two secondary channels in June. Sediments ranged from unconsolidated mud, to mud and fine sand, to coarse sand. Overall, 640 organisms representing 33 taxa were collected (Table 7), with an average macroinvertebrate sample density of 990.1 organisms/square metre.

133. A total of 332 organisms representing 24 taxa were collected from Case Bar secondary channel (TCC) in June (Table 7). The average sample density at TCC was 1097.8 organisms/square metre (Figure 14). Current velocities ranged from 0.3-2.5 fps; substrates ranged from mud and fine sand to coarse sand. Oligochaetes, principally Tubificidae, were the dominant group of macroinvertebrates collected, representing 87.9 percent of the total numbers. *Limnodrilus hoffmeisteri*, *Limnodrilus cervix*, *Limnodrilus maumeensis*, and tubificid immatures were the numerically important species collected from this group. The Chironomidae were next in order of numerical importance (6.9 percent) and were

represented principally by *Glyptotendipes* sp. and *Cryptochironomus* sp.

134. A total of 308 organisms representing 23 taxa were collected at Tar Camp Crossing secondary channel (TCT) in June. The average sample density was 882.5 organisms/square metre. There was no detectable current at TCT during the sampling effort. Bottom substrates ranged from mud, to mud and fine sand, to coarse sand. Oligochaetes, principally Tubificidae, were again the dominant macroinvertebrate group collected, representing over 57.7 percent of the total macroinvertebrates collected. *Branchiura sowerbyi*, *Limnodrilus cervix*, and tubificid immatures were the numerically important species collected in this group. Next in order of numerical importance were the Chironomidae and the ephemerid mayflies *Hexagenia* spp., representing 15.9 and 12.9 percent, respectively. The chironomid population was dominated numerically by *Coelotanypus* sp., *Tanypus stellatus*, and *Polypedilum illinoense*.

135. From the two secondary channels, a total of 28 benthic grab samples were collected in September. Sediment type was predominantly mud and mud-fine sand. A total of 1142 organisms, representing 36 taxa, were collected from the secondary channels (Table 8), yielding an average macroinvertebrate sample density of 1573.5 organisms/square metre.

136. A total of 409 organisms representing 25 taxa (Table 8) were collected at TCC, where the average sample density was 1175.3 organisms/square metre (Figure 14). Sediment type was predominantly mud and mud-fine sand. Oligochaeta, principally Tubificids, were the dominant macroinvertebrate group collected, comprising 56.7 percent of the total numbers. Numerically important species collected in this group were tubificid immatures and *Limnodrilus maumeensis*. Next in order of numerical importance were the Chironomidae and the Chaoboridae, representing 29.3 and 5.6 percent, respectively. The chironomid fauna was numerically dominated by *Polypedilum* nr. *scalaenum*, *Tanypus stellatus*, and *Coelotanypus* sp., while Chaeoboridae were represented by a single species, *Chaoborus punctipennis*.

137. TCT exhibited somewhat higher densities as compared to TCC with 733 organisms being collected representing 25 taxa. The average

sample density for TCT was 1971.1 organisms/square metre, and sediment type was predominantly mud. The Oligochaeta, principally Tubificidae (33.1 percent); the ephemerid mayflies *Hexagenia* spp. (30.9 percent); the pelecypod *Corbicula fluminea* (15.0 percent); and the Chironomidae (14.5 percent) were the dominant macroinvertebrate groups collected. The chironomid fauna was numerically dominated by *Coelotanypus* sp., *Ablabesmyia annulata*, and *Procladius* sp. Numerically important oligochaete species were tubificid immatures, *Aulodrilus pigueti*, *Branchiura sowerbyi*, and *Limnodrilus maumeensis*.

138. The dramatic change in physical conditions in the dike field and natural bank habitats between June and September was not evident in the secondary channel habitats. Current velocity and substrate type, principally mud and fine sand, remained virtually unchanged between the two sampling months. The total number of taxa collected increased only slightly in September (36 taxa) as compared to June (33 taxa). Macroinvertebrate densities were relatively high in both June and September sampling efforts, with community composition being dominated principally by tubificid oligochaetes; chironomid larvae; peleycepods, principally *Corbicula fluminea*; and the ephemerid mayflies *Hexagenia* spp. Samples collected in September exhibited an increase in total numbers for all of the dominant taxa compared to June.

139. Abandoned channel. Eleven samples were collected in the abandoned channel habitat (ACH) in June. Sediment type ranged from mud to mud and fine sand, and the current velocity was a uniform 0.7 fps through most of this habitat. A total of 228 organisms were collected at ACH representing 23 taxa, and the average sample density was 891.1 organisms/square metre. Oligochaetes, principally Tubificidae, dominated the macroinvertebrates collected, comprising 58.3 percent of the total sample. *Branchiura sowerbyi*, *Limnodrilus cervix*, and tubificid immatures were the numerically important species collected in this group. Next in order of numerical importance were the Chironomidae and the ephemerid mayflies *Hexagenia* spp., comprising 15.3 and 12.7 percent, respectively. The chironomid fauna was numerically dominated by *Tanypus stellatus* and *Polypedilum illinoense*.

140. A total of 580 organisms representing 31 taxa were collected at ACH in September, giving an average sample density of 1162.6 organisms/square metre. Substrate type was predominantly mud and fine sand. The macroinvertebrate assemblage colonizing the abandoned channel habitat in September was very similar to that of June. Oligochaetes, principally Tubificidae, were again the dominant macroinvertebrate group collected (36.7 percent). Numerically important tubificid species collected included tubificid immatures, *Aulodrilus pigueti*, and *Branchiura sowerbyi*. Next in order of numerical importance were the ephemerid mayflies *Hexagenia* spp. and the Chironomidae, representing 30.3 and 25.0 percent, respectively. The chironomid fauna was numerically dominated by *Ablabesmyia annulata*, *Polypedilum* nr. *scalaenum*, and *Parachironomus* sp.

141. Physical conditions in ACH closely resembled those encountered in the secondary channel habitat in both June and September, with current velocity and substrate type remaining virtually unchanged. The total number of taxa increased in September (31 taxa) as compared to June (23 taxa), although density estimates remained relatively high in both months. The macroinvertebrate community in June was comprised primarily of tubificid oligochaetes; chironomid larvae; pelecypods, principally *Corbicula fluminea*; and the ephemerid mayflies *Hexagenia* spp. Samples collected in September exhibited an increase in total numbers of all the dominant taxa compared to June.

Comparison of macroinvertebrate composition among habitats

142. Using the CC index,* each habitat was compared to all other habitats, thereby forming a similarity matrix for each of the collection periods. A similarity matrix diagram was then formulated directly from the similarity matrix. In this diagram, habitats showing similarity values equal to or greater than 0.65 are associated by connecting lines. The use of 0.65 as a cutoff value for marked similarity is arbitrary; however, many investigators, including Hanson (1955), Hurd (1961), and

* The CC index was used to compare only those habitats in which bottom grabs were collected.

Beckett (1978), have found 0.65 to be indicative of high biotic similarity.

143. The difference in physical conditions that existed among the various habitats in June is reflected in the similarity matrix diagram (Figure 16). Only two of the seven habitats investigated, DFA and DFB, exhibited marked similarity (→ 0.65) with regard to their macroinvertebrate community composition. It is also apparent from the similarity matrix (Figure 17) that all comparisons between the dike field, secondary channel, and abandoned channel habitats, although not exhibiting

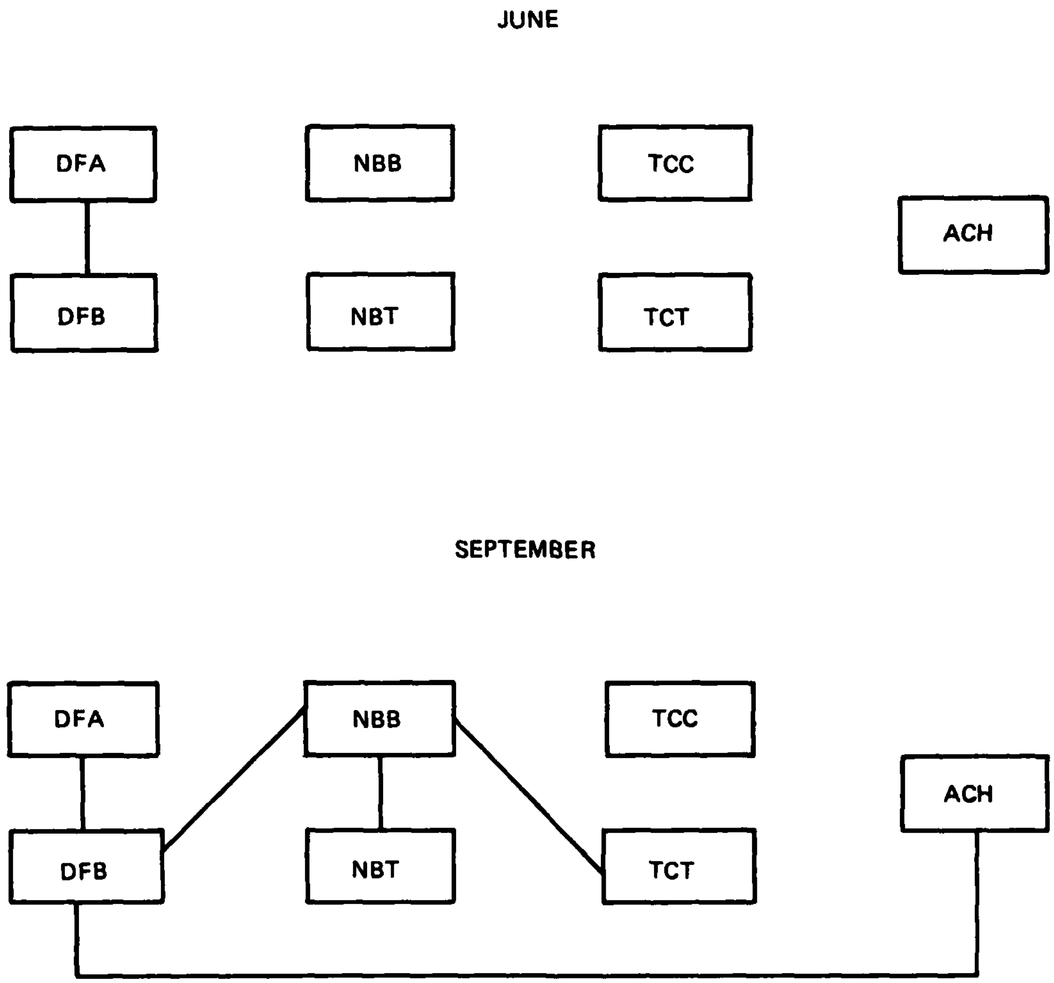

Figure 16. Similarity matrix diagram illustrating the relationship among the macroinvertebrate faunas colonizing aquatic habitats in Pool 5 of the McClellan-Kerr Arkansas River Navigation System. Solid lines connect habitats with similarity values ≥ 0.65

SEPTEMBER \ JUNE	DFA	DFB	NBB	NBT	TCC	TCT	ACH
DFA		0.70	0.44	0.20	0.57	0.50	0.58
DFB	*0.69*		0.62	0.29	0.63	0.58	0.52
NBB	*0.59*	*0.68*		0.45	*0.48*	0.40	0.40
NBT	*0.54*	0.57	*0.74*		0.36	0.13	0.31
TCC	*0.51*	0.57	*0.60*	*0.56*		*0.60*	0.55
TCT	*0.56*	*0.63*	*0.73*	*0.50*	*0.56*		0.52
ACH	*0.55*	*0.66*	0.57	*0.43*	*0.64*	*0.64*	

Figure 17. CC similarity matrix for benthic macroinvertebrate samples collected from Pool 5 of the McClellan-Kerr Arkansas River Navigation System. (Habitat acronyms are defined in Figure 1)

marked similarity at the 0.65 level, did reveal moderately high similarity values (0.50-0.70) in June. In contrast, relativity low compositional similarity values were noted in comparing the natural bank habitat to all other habitats (0.13-0.48), with one exception (DFB-NBB).

144. This similarity matrix reflects the dramatic changes in the biological affinities for the habitats investigated in September, with similarity values increasing in virtually every comparison as compared to June. Five comparisons exhibited marked similarity in September, as opposed to one in June (Figure 16).

PART V: DISCUSSION

Fish Populations

145. Little information relating to Arkansas River fish populations is available for the period prior to construction of the navigation system. A few nonstandardized rotenone collections were made during 1963-1969 by the Arkansas Game & Fish Commission (unpublished) just prior to and during construction of the navigation system; however, the only comprehensive investigation of Arkansas River fishes took place after the waterway was completed (Buchanan 1974). That study documented the present or past occurrence of at least 94 species in the river.

146. As noted earlier, the physical nature of the Arkansas River has changed considerably since completion of the navigation system. The river still exhibits large fluctuations in discharge throughout the year, but erosion, turbidity, and chloride levels are much reduced (Babcock et al. 1980). Whereas at the lowest flows it formerly consisted of warm, shallow pools and side channels within a highly braided main channel, it now consists of a number of relatively deep run-of-the-river impoundments (Babcock et al. 1980). Plankton populations are higher (McNutt 1976), and the benthic community has changed due both to the great extent of riprap (revetment) and stone dikes, which provide the hard substrate required by many invertebrates, and the pooling effect of the dams.

147. Although few preconstruction data are available, it appears that fishes tolerant of or better adapted to these conditions may be more abundant, while species that require a more open-river environment appear to have declined in numbers (Buchanan 1974). These types of species changes were found to occur in other similar projects (Patriarche and Campbell 1958, Carter 1968, Turner 1971, Bhukaswan 1973, and Pennington et al. 1981).

148. Most of the 48 species collected in this study could be considered typical of large lowland rivers. A few of the rarer species, such as the pallid shiner, weed shiner, highfin carpsucker, spotted sucker, shorthead redhorse, and mooneye, may represent stragglers from

tributaries; however, most of the species collected in this study probably maintain at least small populations in the Arkansas River (Buchanan 1974). Our collections generally corresponded to those of Buchanan (1974), and they indicated that considerable changes in the ichthyofauna have occurred since completion of the navigation system.

149. One of the most striking changes has been in the relative abundances of the catfishes. In the Arkansas Game & Fish Commission rotenone samples conducted in the 1960s, blue catfish were considerably more abundant than channel catfish. Flathead catfish, though often collected, were apparently not numerous. Subsequent collections (Buchanan 1974; Arkansas Game & Fish Commission 1982, unpublished data) and those during this study indicate that the channel catfish is now dominant throughout the navigation system. Flathead catfish also appear to be more abundant. Blue catfish are more characteristic of swifter channels and chutes of large rivers, and they appear to decline following impoundment (Pflieger 1975, Trautman 1981). Our collections, which included both yearlings and adult fish, indicate that the blue catfish is still maintaining a sizable population in the Arkansas River, at least in the study reach, and is apparently reproducing successfully. However, as the navigation system matures, a decline in this important commercial species may occur.

150. Several sport species have greatly increased in numbers since completion of the navigation system. Largemouth bass, white and black crappies, and white bass have probably always been present in the river in low numbers. The pooling of the river has increased the preferred habitat of these species, and they now support a considerable fishery. Bluegill probably were common prior to pooling, but their abundance undoubtedly has increased also (Buchanan 1974). The striped bass, introduced in the 1960s, appears to be maintaining at least a small population.

151. Gizzard and threadfin shad were almost certainly part of the Arkansas River fish fauna prior to placement of the dams (Miller and Robison 1973, Buchanan 1974, Pflieger 1975). However, earlier records, along with the Arkansas Game & Fish Commission rotenone samples during

the 1960s, indicated that shad comprised only a small percentage of the fishes. Within 5 years of completion of the navigation system, these species comprised over 50 and 15 percent of the fish, respectively (Buchanan 1974). More recent Arkansas Game & Fish Commission (1982, unpublished data) collections have indicated relative abundances for these species (combined) of 20-40 percent.

152. Gizzard shad comprised only about 11 percent of our collections, and threadfin shad were rare. The most likely explanation is that extensive kills of these species occurred during the very cold winter of 1981-1982. Conversations with local sport and commercial fishermen confirmed this, as they indicated that both species were much more abundant during the summer of 1981. A few seine collections made during July 1983 showed that threadfin shad were probably the single most abundant species in Pool 5 at that time. Because the Arkansas River is at the northern edge of the natural range of this cold-sensitive species, threadfin shad abundance will probably always fluctuate greatly from year to year.

153. Common carp were not abundant in the samples taken for this study, and none of the more recently introduced grass carp (*Ctenopharyngodon idella*) were collected. Buchanan (1974) listed common carp as one of the most numerous large fishes in the river and indicated that grass carp were "taken" all along the navigation system. A rotenone collection made in Pool 5 during July 1982 (Arkansas Game & Fish Commission, unpublished data) documented the presence of many adults of both species. These species will probably continue to increase in abundance in the system.

154. Paddlefish were formerly common in the Arkansas River, and they may still be fairly common in some areas (Buchanan 1974). We collected no specimens of this species, and none of the commercial fishermen to whom we spoke had captured any during 1982. None of the recent rotenone collections of the Arkansas Game & Fish Commission have included this species. However, paddlefish are still taken occasionally in Lakes Dardanelle and Ozark.*

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* Personal Communication, 2 March 1984, Tommie Crawford, Fisheries Division, Arkansas Game & Fish Commission, Little Rock, Ark.

155. The blacktail and red shiners, two closely related minnow species, appear to have undergone population changes since placement of the dams. The blacktail shiner is abundant in the clear lower White River, which joins the Arkansas in the vicinity of the Mississippi River. However, this species was probably not historically common in the Arkansas River itself due to the river's high turbidity. Unpublished collection lists* from the mid-1950's document the presence of only the red shiner in the Arkansas River near the study site. In 1974 Buchanan collected only 115 blacktail shiners during his extensive investigations. Most of these were collected either downstream from Little Rock or from an area just upstream near the mouth of a large, clear tributary. It is likely that the blacktail shiner has increased and will continue to increase in abundance in the navigation system.

156. Two species that we did not collect appear to be declining in the river. At the time of completion of the navigation system, both blue sucker and shovelnose sturgeon were considered common in the Arkansas River. In fact, Buchanan (1974) commented that the Arkansas River blue sucker population was "probably one of the largest and most stable in the entire range of the species," and he noted that commercial fishermen frequently took shovelnose sturgeon. Neither of these species was collected during this study, even though we sampled river habitats where they should have occurred (Pflieger 1975; Smith 1979; Rupprecht and Jahn 1980; Moss, Scanlan, and Anderson 1983; Pennington, Baker, and Bond 1983). Arkansas Game & Fish Commission biologists have collected very few individuals of these species in recent years. Commercial fishermen still take limited numbers of shovelnose sturgeon by fishing immediately downstream of dams; however, blue suckers are now uncommon to rare in their catch.**

157. Aquatic habitats similar to those sampled on the Arkansas River (dike fields, secondary channels, abandoned channels, revetted and natural banks) have been studied in several other modified rivers.

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* Personal Communication, 2 March 1984, Donald Scott, Dept. of Zoology, University of Georgia, Athens, Ga.

** Personal Communication, Tommie Crawford, op. cit.

The combination of habitats differs from river to river, making direct comparisons difficult, and in some rivers such as the Arkansas, the effects of these habitats on the fauna are modified by the effects of dams. Despite this, these habitats seem to affect the faunas in similar ways.

158. Dike fields provide a wide range of depths, currents, and substrates, all of which have been shown to be important habitat components affecting fish distributions (Gorman and Karr 1978, Harrell 1978, Sheldon 1980, Baker and Ross 1981), and these habitats should support many species. A number of studies have indeed shown that dike fields are inhabited by a large number of fish species. Pennington et al. (1980) and Pennington, Baker, and Bond (1983) collected over 50 species of fish from dike fields on the Lower Mississippi River near Greenville, Miss., more than from any other habitat. The dike fields were utilized by sport species such as white bass and crappies; commercial fishes such as catfishes, carpsuckers, buffaloes, and freshwater drum; and many species of forage fish, notably gizzard shad, silversides, minnows, and shiners. For many species, a wide range of size classes was present, indicating that these areas were suitable for many life history stages. Although the dike fields were somewhat different physically, their fish faunas showed high similarity.

159. Studies of the Missouri River (Kallemeyn and Novotny 1977; Robinson 1980; Burress, Krieger, and Pennington 1982; Hesse, Bliss, and Zuerlein 1982) have also shown that dike fields support many fish species. The kinds of species encountered in these studies were similar to those collected in the Mississippi River studies noted above, with sport, forage, and commercial species all being well represented. Robinson's (1980) study of eight Missouri River dike fields showed that despite a wide range of dike types and modifications, the fish populations were very similar.

160. In the Upper Mississippi River, Bertrand (1971) and Bertrand and Garver (1973) found that "larger samples of bluegill, bass, and crappie were...collected" when wing dikes were exposed during low water levels. Pierce (1980) also collected a larger number of species in the

vicinity of emergent wing dams (= dikes), which formed large slack-water areas, than around submerged wing dams, which did not form such areas. Typical slack-water species such as largemouth bass, blue-gills, crappies, pumpkinseed (*Lepomis gibbosus*), and orangespotted sunfish were collected.

161. The results of these studies parallel ours in showing that dike fields support one of the most speciose ichthyofaunas of all river habitats. They also showed that the relative abundance of the various species tends to vary with discharge, with species more typical of standing water becoming more abundant as the dikes become emergent.

162. Revetments in the Lower Mississippi River consist mainly of articulated concrete mattress (Keown et al. 1977), and they appear to provide a comparatively rigorous habitat. Pennington et al. (1980) and Pennington, Baker, and Bond (1983) found that this habitat was typified by larger, more robust species capable of negotiating the swift currents. These species included catfishes, freshwater drum, blue sucker, shovelnose sturgeon, buffaloes, carp, river carpsucker, adult gizzard shad, threadfin shad, and skipjack herring. Revetments on most other rivers, including the Arkansas River, consist of stone riprap (Keown et al. 1977).

163. Many of the species collected in Mississippi River revetment habitats were also collected in similar habitat of the MissouriRiver. Kallemeyn and Novotny (1977) captured carp, river carpsucker, shorthead redhorse, goldeye, blue sucker, freshwater drum, gizzard shad, channel catfish, white bass, smallmouth buffalo, and black crappie along revetments. Hesse, Bliss, and Zuerlein (1982) found carp, shorthead redhorse, freshwater drum, channel catfish, and flathead catfish to be dominant along revetments. Burress, Krieger, and Pennington (1982) collected mainly carp, white bass, sauger, shovelnose sturgeon, walleye, and yellow perch along other Missouri River revetments.

164. In the present study, two distinct ichthyofaunas were collected from revetment habitats during the two sampling periods. Conditions in June were typical of those most often encountered along revetments, with relatively swift currents predominating. Such currents

probably preclude the presence of fishes adapted to slower currents, such as most species of sunfishes (*Lepomis*), crappies, largemouth bass, and most minnows and shiners. Consistent with this presumption, our catch consisted mostly of catfishes, river carpsucker, freshwater drum, and white bass. Very few gizzard shad, bluegill, longear sunfish, and crappies were captured. This catch was, thus, similar to that reported for revetments in the Lower Mississippi River and the Missouri River.

165. During September, slack-water conditions prevailed in all habitats due to pooling by the dams, and a very different fish community inhabited the revetments. Bluegill, gizzard shad, longear sunfish, white crappie, white bass, freshwater drum, and flathead catfish were most abundant, with the last two species being less numerous than in June. Wapora, Inc. (1982) found large populations of bluegill, largemouth bass, white crappie, gizzard shad, carp, freshwater drum, white bass, flathead catfish, and bigmouth buffalo along Kaskaskia River (Illinois) revetments when currents were slow. From an investigation of the invertebrate composition in stomach samples and in the substrates of several river habitats, Himelick, Sale, and Herricks (1981) determined that adult bluegill commonly fed on invertebrates associated with the stone riprap of revetments in the Kaskaskia River.

166. Natural bank fish populations appear to differ from revetted bank fish populations more in the relative proportions of their constituent species rather than in the particular species using them. These differences in relative abundance at any given time may be large (Pennington et al. 1980; Burress, Krieger and Pennington 1982; Pennington, Baker, and Bond 1983) or they may be relatively small (Kallemeyn and Novotny 1977; Wapora, Inc. 1982). Natural and revetted bank ichthyofaunas in this study showed high similarity at both high and low discharges.

167. In general, the two natural banks were more similar to each other than were the two revetted banks, a finding also made by Pennington, Baker, and Bond (1983) for the Lower Mississippi River. At any given time, natural and revetted banks generally showed rather low similarity to each other in the Lower Mississippi River (Pennington

et al. 1980; Pennington, Baker, and Bond 1983) and in one Missouri River study (Burress, Krieger, and Pennington 1982). However, with the exception of carp, which were abundant only along revetments, Kallemeyn and Novotny (1977) collected fairly similar fish faunas from Missouri River revetments and main channel border areas (= natural banks).

168. Secondary channels may be either permanent, in which a current exists at all river discharges, or temporary, in which a current exists only at relatively high discharges. The difference in physical character between these two types appears to lead to significant differences in their fish communities. In the Lower Mississippi River, Pennington et al. (1980) collected only 12 species of fish in trammel and hoop nets from a permanent secondary channel that was physically similar to the main channel. Freshwater drum, carp, flathead catfish, channel catfish, and shovelnose sturgeon were the most frequently collected species. Burress, Krieger, and Pennington (1982) collected only nine species from a chute (= secondary channel) on the Missouri River. However, Kallemeyn and Novotny (1977) collected up to 20 species from chutes in the Missouri River in which "there was a current during most of the study period."

169. Studies conducted on the Middle and Upper Mississippi River have shown that side channels (= secondary channels) support a wide variety of fish species depending upon habitat characteristics (Bertrand and Allen 1973, Bertrand and Dunn 1973, Bertrand and Garver 1973, Bertrand and Lockart 1973, Bertrand and Miller 1973, Bertrand and Russell 1973). Overall, the numbers of species such as bass, crappies, and sunfishes increased as side channels became more lentic in character.

170. A particularly pertinent study of side channels in the Mississippi River was conducted by Ellis, Farabee, and Reynolds (1979). Three secondary channels that varied in character from lotic to lentic were sampled to determine what differences existed in their ichthyofaunas. Nearly identical numbers of species and individuals were captured in the three areas, but the relative abundances of the species were different and they were related to the physical characteristics of the habitats. Gizzard shad, largemouth bass, and white crappie were most

abundant in the lentic channel, and bowfin, warmouth, and highfin carpsucker were found only there. Freshwater drum and black crappie were most abundant in the lentic and intermediate current side channels, while carp, goldeye, white bass, and sauger were found mainly in the fast and intermediate current side channels. Skipjack herring and mooneye were captured almost exclusively in the lotic side channel.

171. In the present study, secondary channels supported as many or more species of fish than any other habitat. Catch rates for most gears were also equal to or greater than those from any other habitat. The two secondary channels in this study (TCC and TCT) showed physical and biological characteristics that paralleled those of Ellis, Farabee, and Reynolds (1979). During June, when the physical differences between secondary channels were greatest, the slack-water channel yielded greater numbers of slack-water species. River carpsucker, silversides, channel catfish, bluegill, longear sunfish, white crappie, largemouth bass, yellow bass, and striped bass were all more common there, while blue catfish, white bass, and freshwater drum were more common in the faster-water habitat.

172. Abandoned channels support a variety of fish species, some of which are quite characteristic of this habitat. Pennington et al. (1980) collected predominantly (in decreasing order) gizzard shad, river carpsucker, freshwater drum, skipjack herring, common carp, blue catfish, channel catfish, crappies, shortnose gar, bluegill, striped bass, and bowfin from an abandoned channel in the Lower Mississippi River. Spotted gar, paddlefish (*Polyodon spathula*), bullheads (*Ictalurus natalis*, *I. nebulosus*, *I. melas*), and warmouth were characteristic of this habitat. The followup study (Pennington, Baker, and Bond 1983) showed much the same fauna to inhabit the abandoned channel, with the addition of larger numbers of threadfin shad and white bass.

173. Bertrand (1971), Bertrand and Dunn (1973, 1974), Bertrand and Miller (1973), Bertrand and Russell (1973, 1974), and Bertrand and Pulley (1974) reported on fish collections from sloughs (= abandoned channels) in the Middle and Upper Mississippi River. The lists of species collected were very similar to those noted above for the Lower

Mississippi River but contained somewhat greater numbers of largemouth bass and small sunfishes.

174. In this study, two somewhat different sets of species were collected from the abandoned channel. Channel and blue catfishes and freshwater drum were dominant in June when a current existed. In September, however, gizzard shad, crappies, spotted gar, and river carpsucker were most common. Spotted gar and bowfin were especially characteristic of this habitat.

175. Navigable rivers involving Corps projects appear to have much in common in terms of the relationships of their aquatic habitats. Dike fields, at least where they do not undergo rapid, severe sedimentation, support a wide variety of fishes. They are physically diverse, and it is this physical heterogeneity that fosters their high biotic diversity. Secondary channels are more variable habitats, rivaling dike fields in biotic diversity in some rivers, while having depauperate faunas in others.

176. The principal controlling featur(appears to be the annual current regime. Permanent secondary channels, such as PCA of Pennington et al. (1980) and Beckett et al. (1983), have strong flows and coarse substrates, and they are generally more similar to natural banks or the main channel. Temporary secondary channels, such as those in this study, are often very similar to dike fields, both physically and biotically. Abandoned channels in most rivers appear to be rather unique habitats, and a number of distinctive species are found in them. They are most similar to dike fields and temporary secondary channels during late summer and fall low-flow periods. Natural and revetted banks generally support the fewest species of all river habitats, although they, too, can vary from river to river.

17,. Condition factors of white crappie collected during this study were somewhat lower than those given by Carlander (1977) for lakes. The K values of our Arkansas River specimens were closer to, but still below, those of Missouri River impoundments.

178. Carlander (1969) gives mean K values for gizzard shad of from 0.91-1.11, most commonly about 0.95, values well above our monthly

means of 0.69 and 0.88. The consistent increase in gizzard shad condition factors in all habitats from June to September may have two causes. Since shad spawn during April to early June, a relatively low mid- to late-June K value may very likely be due to weight loss during spawning. Secondly, the planktonic food available during September, when the river was pooled, may have been more abundant than during June. Since gizzard shad are plankton feeders, an increase in the food supply should lead to an increase in condition.

179. Channel catfish condition factors from the Arkansas River were at (June) or slightly below (September) the low end of the range given by Carlander (1969). The K values of blue catfish, while not as comparatively low as those of channel catfish, were still below those from most other states. Of the catfishes, only flathead catfish showed condition factors similar to those from other river systems.

180. It is possible that gear selectivity produced, at least in part, the size distribution differences noted for some species. Gill nets work best in standing water, while hoop nets are generally more effective, at least for many species, in flowing water. This difference was well illustrated by the relative catches of these gears in the two secondary channels. In TCT, no current was present even in June, and gill nets captured all but 4 of the 199 channel catfish. In TCC, where both flowing and slack areas occurred, the catches of channel catfish were nearly equal in both gears (23 in gill nets and 33 in hoop nets).

181. The number of smaller fish collected by the two gear types might also have been due to their respective methods of capture. Gill nets had a panel of 1-in.-mesh webbing that was at least partially effective for capturing fish as small as 75 mm TL. And, because of the loose set of gill nets, even the somewhat larger mesh sizes can capture fish by entanglement. In contrast, the thick, sturdy, 1-in. webbing of the hoop nets is held rather rigid when set, making capture by entanglement very difficult. Small catfish can easily escape through the meshes if they are less than about 125 mm TL, although the exact size varies with species. Therefore, gill nets may have "fished smaller" than hoop nets and thus produced spurious size distributions.

182. Two considerations argue against this size selectivity effect. Gill nets should have fished equally well in all habitats during September when there was no current in any habitat. Differences at this time must therefore reflect actual differences in fish occurrence and abundance. Secondly, during June, the gill nets were set only in areas of reduced or negligible current, even in habitats such as TCC which had current in most areas. Therefore, the relatively low number of small fishes collected in many habitats during June is difficult to explain except by assuming that they were, indeed, not abundant there.

Macroinvertebrate Collections

183. While data collected from the dike (DFA and DFB) and revetment (RVH and RVB) structures using rock basket samplers were not quantitative, these habitats appear to be the most productive of all habitats sampled. Mathis et al. (1981) found dike structures to be the most productive macroinvertebrate habitat sampled in a similar study on the Lower Mississippi River.

184. In June, the macroinvertebrate fauna colonizing the dike and revetment structures was comprised principally of hydropsychid (Hydropsychidae) and polycentropodid (Polycentropodidae) caddisflies, chironomid larvae (Chironomidae), and amphipods. However, differences in current velocity among the habitats were expressed in differences in the relative abundance of the dominant macroinvertebrate groups. Those habitats located near the upstream end of the pool, RVH and DFA, where moderate currents were present, were characterized by a lotic assemblage of macroinvertebrates dominated by *Hydropsyche orris* (Hydropsychidae) and *Cheumatopsyche* sp. (Hydropsychidae). Both of these species are filter feeders and are therefore dependent upon current (Merritt and Cummins 1978). Conversely, those habitats located near the downstream end of the study pool, DFA and RVB, were subjected to little or no current and were therefore characterized by a lentic assemblage comprised primarily of polycentropodid caddisflies, principally *Cyrnellus fraternus* and amphipods.

185. The effect of current velocity on macroinvertebrate community

structure has been intensively investigated in streams and rivers (Fremling 1960, Neel 1963, Jagg and Ambuhl 1964, Edington 1965, Chutter 1969, and Beckett and Miller 1982). Of particular interest are those investigations conducted by Fremling (1960) and Beckett and Miller (1982), as their findings on the Mississippi and Ohio Rivers with regard to current preference of certain Trichoptera larvae paralleled those we noted on the Arkansas River in June. Beckett and Miller (1982) investigated the effect of contrasting current velocities on macroinvertebrate colonization in the Ohio River. They noted that multiplate samplers placed below a dam in appreciable current were colonized by *Hydropsyche orris* while samplers placed above the dam where there was no appreciable current were not. Fremling (1960) noted similar results on the Upper Mississippi River while investigating the ecological distribution of caddisfly larvae. Results of his investigation showed *Hydropsyche orris* to be current-dependent, with high densities found only in areas of appreciable current. Results of Fremling's work also indicate that the caddisfly larvae *Hydropsyche orris* is replaced by *Cyrnellus fraternus* as current velocity decreases, as was also evidenced in our study.

186. The Chironomidae were the most diverse group collected at all sites. Certain species such as *Glyptotendipes* sp., *Dicrotendipes neomodestus*, and *Dicrotendipes nervosus* (Type I), which are typical of slow current environments (Simpson and Bode 1980), were collected in higher numbers at Brodie Bend revetment (RVB) and Case Bar dike field (DFB) than at Estes Place dike field (DFE) and Harris Bend revetment (RVH), again reflecting the effect of current on macroinvertebrate community composition.

187. In September, an overall increase in both density and number of taxa was noted. The macroinvertebrate fauna was characterized primarily by polycentropodid caddisflies, principally *Cyrnellus fraternus*, chironomid larvae (Chironomidae), and the amphipod *Corophium lacustre*. The lotic-adapted hydropsychid caddisflies, which had dominated the macroinvertebrate fauna in moderate-current habitats in June, accounted for only 1 percent or less of the total numbers. The increase in the relative abundance of *Corophium lacustre* (Amphipoda) in all samples

collected in September reflected the lentic conditions that existed during this time, as amphipods are poorly adapted to resist current (Ward 1976).

188. Dike field habitats (DFA and DFB) were characterized in June by high to moderate currents, varying substrate types, and relatively low macroinvertebrate densities. Beckett et al. (1983) observed similar conditions in dike fields on the Lower Mississippi River during periods of moderate to high discharge. The dominant macroinvertebrates collected in grab samples in the Arkansas River dike fields at this time were tubificid oligochaetes represented principally by tubificid immatures, *Branchiura sowerbyi*, and *Limnodrilus maumeensis*. Chironomidae were next in order of numerical importance, being represented principally by *Polypedilum illinoense*, *Coelotanypus* sp., and *Tanypus stellatus*. Certain unique areas within the dike fields in which there was no negligible current and a mud substrate were dominated by species such as *Tanypus stellatus*, which prefers a soft mud substrate (Roback 1977).

189. Physical conditions within the dike fields were greatly altered in September as compared to June. No detectable current was evident in either DFA or DFB, bottom substrates were fairly uniform (silt), and relatively high macroinvertebrate densities were noted. Macroinvertebrate composition was dominated by tubificid oligochaetes and chironomid larvae; however, certain other groups that were collected in relatively low numbers in June became numerically important in September. Naidid worms (Oligochaeta) were numerically important in DFA and very common in DFB during September. The virtual absence in June of this group is in part attributable to the existing bottom-scouring conditions. *Aulodrilus piqueti* (Tubificidae), which was collected infrequently in the predominantly coarse sand substrates in June, became the dominant oligochaete collected in the dike fields in September. This particular species exhibits a preference for a muddy sand substrate (Fomenko 1980) which had become the dominant substrate present in September. Other numerically important species collected in September that reflect a lentic community and a more stable substrate were the Chaoboridae (Diptera), represented by *Chaoborus punctipennis*, and the epheremid mayflies *Hexagenia* spp.

190. The phenomenon exhibited by the dike field habitat on the Arkansas River, in which a lotic macroinvertebrate assemblage exists during periods of moderate to high flow and a lentic macroinvertebrate assemblage prevails during low flow, has also been observed in dike fields on the Lower Mississippi River (Beckett et al. 1983).

191. Conditions encountered at the natural bank habitat, NBB and NBT, were somewhat similar to those of the dike fields. In June the natural banks were characterized by sandy substrates, high current velocities, and low density estimates. The low density estimates can be explained in part by the high current velocities and the unstable shifting sand substrate prevalent at that time. The macroinvertebrate fauna colonizing the natural banks in June was comprised primarily of tubificid oligochaetes, chironomid larvae, and amphipods, principally *Gammarus fasciatus*.

192. The alteration in physical conditions at the dike field habitat in September was also noted at the natural banks. There was no detectable current, and substrate type was typically silt. Amphipods, which accounted for 43.2 percent of the total sample numbers in June, exhibited a dramatic increase in relative abundance, accounting for 79.2 and 83.2 percent, respectively, at NBB and NBT.

193. A phenomenon that is unexplained is the absence of the amphipod *Gammarus fasciatus* from all samples collected in September, while the amphipod *Corophium lacustre* was present in very high numbers. The presence of this particular species, which appears to have been introduced to this system in recent years,* is of special interest as it is the dominant macroinvertebrate colonizing the natural banks. This species is normally found upon submerged plants or animals; however, specimens have been collected from mud and even coarse sand substrate (Feeley and Wass 1971). Specimens collected along the natural bank habitats are believed to have been associated with submerged grasses and twigs collected in the grab samples. The natural bank habitat exhibited the highest density estimates from bottom substrates sampled in September.

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* Personal Communication, 7 February 1984, Dr. Richard Heard, Gulf Coast Research Laboratory, Ocean Springs, Miss.

194. The dramatic change in physical conditions in the dike field and natural bank habitats from June to September was not evident in the secondary channel habitats. Current velocity and substrate type remained virtually unchanged, and the macroinvertebrate fauna collected in both June and September was indicative of a lentic environment characterized by a relatively homogeneous substrate of mud and fine sand. These findings are somewhat different from those made by Beckett et al. (1983) in a secondary channel habitat on the Lower Mississippi River. They found this habitat type to be riverine in nature at all river stages, and it supported a sparse lotic macroinvertebrate assemblage comprised primarily of sand-dwelling chironomids, specifically *Chernovskiia orbicus* and *Robackia claviger*.

195. These differences in findings are explained by the fact that the secondary channels investigated on the Arkansas River, unlike those studied on the Lower Mississippi River, have dikes located at the upstream end of the channel. These structures restrict flow into the channels, thereby maintaining lentic conditions except during periods of extremely high discharge. The macroinvertebrate community composition in the secondary channel habitat reflected these "lakelike" conditions, with tubificid oligochaetes, chironomid larvae, and ephemerid mayflies maintaining relatively high densities in both June and September.

196. In the abandoned channel habitat, current velocity and substrate type remained virtually unchanged in September as compared to June. The macroinvertebrate fauna was characterized typically by tubificid oligochaetes, dipteran larvae, and ephemerid mayflies during both sampling efforts. Studies conducted on the Lower Mississippi River (Mathis, Bingham, and Sanders 1982; Beckett et al. 1983), very similar in nature to this study, have shown this habitat to be highly productive and lentic in nature regardless of river stage. This study showed similar results, with the abandoned channel habitat maintaining a relatively stable macroinvertebrate community comprised primarily of lentic-adapted organisms during both the June and September sampling efforts.

197. During June, moderately high similarity values were noted among the dike field, secondary channel, and abandoned channel habitats

(see Part IV, Results). Conversely, low compositional similarity values were noted when the natural bank habitat was compared to all other habitats, with only one exception (DFB-NBB). This can be explained in part by the fact that although physical conditions encountered in the dike field, secondary channel, and abandoned channel habitats differed in June, those differences, namely current velocity and substrate type, were not so great as to reflect wide compositional dissimilarities with regard to the benthic communities colonizing those habitats. In contrast, physical conditions encountered at the natural bank habitat were somewhat different from those encountered in all other habitats, making this habitat somewhat more "distinctive." Thus, relatively low similarity values are noted when the natural banks are compared to other habitat types.

198. In September, drastic changes in the biological affinities for the habitats investigated were noted as similarity values increased in virtually every comparison. This increase in similarity among habitats is explained by the stable conditions which existed at this time when there was no detectable current and silt was the common substrate encountered in all habitats.

199. This similarity matrix reflects the dramatic changes in the biological affinities for the habitats investigated in September, with similarity values increasing in virtually every comparison as compared to June. Five comparisons exhibited marked similarity (Figure 16) in September, as opposed to only one in June.

PART VI: CONCLUSIONS

200. The navigation structures and mode of operation of the McClellan-Kerr Arkansas River Navigation System have a direct impact on the macroinvertebrate and fish populations that inhabit the system. The structures (dikes and revetments) provide large areas of hard substrates suitable for a number of macroinvertebrate species. The dikes also create areas of reduced current velocities suitable for many species of fish. The controlled release of water for navigation purposes results in periods of high discharge alternating with periods of negligible discharge, thereby creating lentic conditions during certain times of the year and lotic conditions at others. The macroinvertebrate and fish communities of the aquatic habitats reflect this variation in hydraulic regimes.

201. The fish communities of Arkansas River aquatic habitats appeared to be structured primarily by current, and to a lesser extent, substrate. During high discharge periods, both the habitats and their fish communities were most distinct. Revetments, natural banks, and swift portions of dike fields and one secondary channel were inhabited by larger, more streamlined species or bottom-oriented species such as catfishes and freshwater drum, which can withstand the strong currents. Areas of quieter water in abandoned channels, secondary channels, and dike fields supported many of these species; in addition, they supported many typically slack-water forms such as sunfishes, basses, shad, minnows, silversides, and gars.

202. During June the slack-water secondary channel appeared to be the most productive habitat, with the faster-water secondary channel and the dike fields being the next most productive. Revetted banks, natural banks, and the abandoned channel were the least productive.

203. Slack currents and more homogeneous substrates in September resulted in relatively similar fish communities in all habitats. The primary difference between the two sampling periods was that during September the slack-water fish species, like the slack-water macroinvertebrates, invaded habitats they could not use in June. Dike fields and

secondary channels appeared to be highly, and equally, productive at this time. The revetted and natural banks and the abandoned channel, though more productive than in June, were still less productive habitats overall. Considerably greater numerical catches were made with almost every gear in almost every habitat during September. Much of this increase was due to recruitment of young-of-year fishes; however, a slight increase in the number of adult fish of many species was noted.

204. On the rock substrate of the dike and revetment structures, higher current velocities favor lotic-adapted species such as the caddisflies *Hydropsyche orris* and *Cheumatopsyche* sp., while slower currents tend to favor caddisfly species such as *Cyrnellus fraternus* and *Neureclipsis crepuscularis*. In the absence of current, there is a reduction in the numbers of the lotic-adapted species but an increase in total macroinvertebrate densities, as the lentic species occupy the habitat vacated by the lotic-adapted species. This epilithic fauna colonizing the dike and revetment structures comprises a diverse group that is present in large numbers. Although the data collected from the dike and revetment structures were not directly comparable to those from bottom grabs, the riprap appeared to be the most productive substrate sampled.

205. The macroinvertebrate community inhabiting the bottom substrates of the Arkansas River exhibits variation not only in community structure but also in density, depending upon the hydraulic regime. During periods of high discharge, areas subjected to extreme current velocities (dike fields, natural banks) exhibit a coarse sand substrate and a depauperate macroinvertebrate community; areas subjected to either moderate current or pooled conditions (secondary and abandoned channels) exhibit a silt substrate and a benthic community of greater stability. Dike fields and natural bank bottom substrates exhibit low macroinvertebrate densities during periods of high flow and are colonized principally by burrowing forms of macroinvertebrates such as tubificid oligochaetes and chironomid larvae. As current velocity decreases and a more stable substrate predominates, these habitats become more highly productive and are characterized by a more diverse group of macroinvertebrates. Conversely, the abandoned channel and secondary habitats appear to maintain

stable macroinvertebrate communities regardless of flow rate. These areas are of immense biological importance to this river system as they are the probable source of macroinvertebrates which facilitate the recolonization of those habitats severely affected by the bottom scouring common during periods of high flow.

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Table 1

Units of Effort for Each Gear Type Used in Collecting Fishes from the Arkansas River During June and September 1982

Habitat**		June ES	June HN	June EG	June SN	September ES	September HN	September EG	September SN
ACH		5	10	4		5	9†	4	
DFA	Pool 1	5	10			5	10	4	5
	Pool 2	5	10	2	5	5	10	4	5
	Bar††	5	10		5	5	10		5
DFB	Pool 1	5	10	2	5	5	10	4	5
	Pool 2	5	10		5	5	10	4	5
	Bar	5	10			5	10		
NBB		5	10			5	10		
NBT		5	10			5	10		
RVB		5	10			5	10		
RVH		5	10			5	10		
TCC		5	10	4	5	5	10	4	5
TCT		5	10	4	5	5	10	4	5

Gear*

* ES = electroshocker, HN = hoop net, EG = gill net, SN = seine. Numbers under HN and EG are net-days.

** Habitat acronyms are defined in Figure 1.

† One HN lost on last sampling day; not reset.

†† Channel side of middle bar.

Table 2

Common and Scientific Names of Fishes Collected from the Arkansas River

Common Name	Scientific Name
Gars	Lepisosteidae
Longnose gar	*Lepisosteus osseus*
Shortnose gar	*Lepisosteus platostomus*
Spotted gar	*Lepisosteus oculatus*
Bowfins	Amiidae
Bowfin	*Amia calva*
Herrings	Clupeidae
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Skipjack herring	*Alosa chrysochloris*
Mooneyes	Hiodontidae
Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*
Minnows and carps	Cyprinidae
Common carp	*Cyprinus carpio*
Blacktail shiner	*Notropis venustus*
Red shiner	*Notropis lutrensis*
Mimic shiner	*Notropis volucellus*
River shiner	*Notropis blennius*
Pallid shiner	*Notropis amnis*
Emerald shiner	*Notropis atherinoides*
Silverband shiner	*Notropis shumardi*
Weed shiner	*Notropis texanus*
Ghost shiner	*Notropis buchanani*
Pugnose minnow	*Notropis emiliae*
Bullhead minnow	*Pimephales vigilax*
Suckers	Catostomidae
River carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
Highfin carpsucker	*Carpiodes velifer*
Smallmouth buffalo	*Ictiobus bubalus*
Bigmouth buffalo	*Ictiobus cyprinellus*
Spotted sucker	*Minytrema melanops*
Shorthead redhorse	*Moxostoma macrolepidotum*
Freshwater catfishes	Ictaluridae
Channel catfish	*Ictalurus punctatus*
Blue catfish	*Ictalurus furcatus*
Flathead catfish	*Pylodictis olivaris*
Silversides	Atherinidae
Inland silverside	*Menidia beryllina*
Brook silverside	*Labidesthes sicculus*

(Continued)

Table 2 (Concluded)

Common Name	Scientific Name
Livebearers	Poeciliidae
Mosquitofish	*Gambusia affinis*
Sunfishes	Centrarchidae
Warmouth	*Lepomis gulosus*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Longear sunfish	*Lepomis megalotis*
Green sunfish	*Lepomis cyanellus*
Orangespotted sunfish	*Lepomis humilis*
Black crappie	*Pomoxis nigromaculatus*
White crappie	*Pomoxis annularis*
Largemouth bass	*Micropterus salmoides*
Spotted bass	*Micropterus punctulatus*
Perches	Percidae
River darter	*Percina shumardi*
Temperate basses	Percichthyidae
White bass	*Morone chrysops*
Yellow bass	*Morone mississippiensis*
Striped bass	*Morone saxatilis*
Drums	Sciaenidae
Freshwater drum	*Aplodinotus grunniens*

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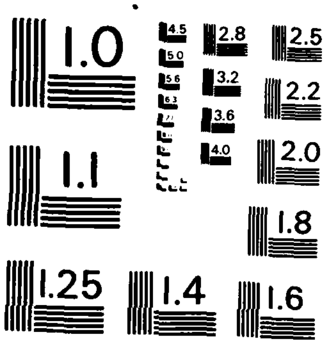

MICROCOPY RESOLUTION TEST CHART
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Table 3

One-Way Analysis of Variance (ANOVA) Results for

Arkansas River Catch-Per-Unit-Effort Data

Sampling Period	Criterion Variable*	Gear**	F	Degrees of Freedom	Error Mean Square	Observed Significance Level†
June	C/f	EG	8.04	4,11	0.575	0.003††
		ES	3.60	12,52	0.433	0.001††
		HN	1.48	12,117	0.647	=0.141
		SN	2.41	5,24	0.451	=0.066††
	C/y	EG	8.13	4,11	0.407	0.003††
		ES	3.84	12,52	6.418	0.001††
		HN	1.50	12,117	5.159	=0.134
		SN	0.63	5,24	0.905	=0.678
September	C/f	EG	6.63	6,21	0.172	0.001††
		ES	1.82	12,52	0.699	=0.070††
		HN	6.31	12,116	0.434	0.001††
		SN	2.23	6,28	1.892	=0.069††
	C/y	EG	1.74	6,21	0.268	=0.160
		ES	0.71	12,52	1.885	=0.736
		HN	3.28	12,116	4.570	0.001††
		SN	1.64	6,28	1.910	=0.174

* C/f = numerical catch per unit effort; C/y = weight catch per unit effort. Values were transformed as log (X + 1) before analysis.

** EG = experimental gill net; ES = electroshocker; HN = hoop net; SN = seine.

† The observed significance level is the likelihood of obtaining, due to chance, an F-ratio higher than that calculated.

†† Duncan's New Multiple Range Test employed following ANOVA.

Species and Number of Fishes Collected

Species	ACH		DFA POOL 1			DFA POOL 2			DFA BAR		DFB
	ES/HN	EG	ES/HN	EG	SN	ES/HN	EG	SN	ES/HN	SN	ES/HN
Longnose gar							2	3			
Shortnose gar		2				1	2				
Spotted gar		2								1	
Lepisosteus spp.											
Bowfin											
Gizzard shad	1		2			4	5	33	7		
Threadfin shad											
Skipjack herring											
Clupeidae											
Goldeye		1									
Mooneye											
Common carp	1								1		
Blacktail shiner								55		17	
Red shiner								105		71	
Mimic shiner											
River shiner											
Pallid shiner											
Emerald shiner											
Silverband shiner											
Weed shiner											
Ghost shiner											
Pugnose minnow											
Notropis spp.											
Bullhead minnow								5		14	
Pimephales sp.											
River carpsucker	1	1	2			1	5	2	6	13	
Quillback											
Highfin carpsucker							1				
Smallmouth buffalo											
Bigmouth buffalo											
Spotted sucker											
Shorthead redhorse											
Channel catfish	21	2	7			17	2		103		26
Blue catfish	11		6			24	2		8		10
Flathead catfish	6		14			4	1		4		2
Inland silverside								76		36	
Brook silverside											
Mosquitofish								9		2	
Warmouth											
Bluegill								31			
Redear sunfish											
Longear sunfish											
Green sunfish											
Orangespotted sunfish											
Lepomis spp.								10			
Black crappie								9			
White crappie	1		1					10			
Pomoxis spp.											
Largemouth bass								3		3	
Spotted bass								1			
River darter											
White bass		1								3	
Yellow bass											
Striped bass			1			1	1	1	1		
Morone spp.										2	
Freshwater drum	32	1	17			10	1		1	1	3
Total number	74	10	50			62	22	353	131	163	41
Species in gear	8	7	8			8	10	14	8	10	4
Species in habitat		12	8					20		16	

* Habitat acronyms are defined in Figure 1. Gear types: ES = electroshocker, HN = hoop net, E

Table 4

cted from the Arkansas River, June 1982, by Habitat and Gear Type*

DFB POOL 1			DFB POOL 2			DFB BAR	NBB	NBT	RVB	RVH	TCC			TCT			
HN	EG	SN	ES/HN	EG	SN	ES/HN	ES/HN	ES/HN	ES/HN	ES/HN	ES/HN	EG	SN	ES/HN	EG	SN	TOTAL
					1											2	8
	3											1			3		12
	2														4		9
		2			1												3
																	0
	1		1		3			1	1	2	22	55		25	48	15	226
																	0
																	0
																	0
												2			3		6
															7		7
	1							1	2								6
		36			57								2			17	184
		116			144								30			31	497
													1				1
																	0
																	0
																	0
																	0
																	0
		1															1
																	0
																	0
		42	1		17								11			14	104
																	0
	5						2	1	1	13	4		1	1	24		83
																	0
																	1
																	0
																	0
																	0
						1				1							2
	6	1	27		1	35	24	42	17	21	34	23	2	4	115		530
			6			5	6	8	17	3	50	31		14	29		230
	1		18			6	18	11	13	11	1			2			112
		2[illegible]			25								7			196	363
																	0
		2			2								2			4	21
																	0
		10							3				6	4	2	5	61
																	0
		3			[illegible]		1		2				4		1	7	21
																	0
		1															1
					1								7			7	25
									1				2		3		15
		2			4									4	5		27
																	0
		6			1		1		1							3	18
		2			1								2				6
		1															1
	1	2							2	6	6	4	7	5	4	1	42
															3		3
									1	1		7		1	14		29
		5			1												8
	2		8			3	14	17	16	9	80	5		5	26		251
	22	255	61		262	50	66	81	77	67	197	128	84	65	291	302	2,914
	9	16	6		12	5	7	7	13	9	7	8	13	10	16	12	32
		23			16	5	7	7	13	9			20			24	

EG = experimental gill net, SN = seine.

Species and Number of Fishes Collected

Species	ACH ES/HN	ACH EG	DFA POOL 1 ES/HN	DFA POOL 1 EG	DFA POOL 1 SN	DFA POOL 2 ES/HN	DFA POOL 2 EG	DFA POOL 2 SN	DFA BAR ES/HN	DFA BAR SN	ES/H
Longnose gar				2			2				
Shortnose gar				4		1					1
Spotted gar	5	8				1					
Lepisosteus spp.											
Bowfin	1	1		1							
Gizzard shad	79		49	21		92	33		59		132
Threadfin shad	2					1			2		1
Skipjack herring	3	1		1			2				
Clupeidae											
Goldeye											
Mooneye											
Common carp	1	1	1			1	2		1		2
Blacktail shiner					321			336		71	
Red shiner					499			322		137	
Mimic shiner					1						
River shiner								21		3	
Pallid shiner					1						
Emerald shiner								1		1	
Silverband shiner					9			3		3	
Weed shiner											
Ghost shiner											
Pugnose minnow											
Notropis spp.					3						
Bullhead minnow					41			45		3	
Pimephales sp.											
River carpsucker	1	10		7		1	28				
Quillback							9				
Highfin carpsucker											
Smallmouth buffalo											
Bigmouth buffalo				1			1				
Spotted sucker		1									
Shorthead redhorse											
Channel catfish	2	7	4	4		3	13		5		3
Blue catfish	1		1	4			8				
Flathead catfish		1	3						1		
Inland silverside					421			1,010		305	
Brook silverside					45			13		9	
Mosquitofish					3			1		1	
Warmouth											
Bluegill	4		9			9	1		1		4
Redear sunfish		1				1					
Longear sunfish	1	1			1	2					
Green sunfish						1					
Orangespotted sunfish											
Lepomis spp.					8						
Black crappie	2					9					
White crappie	17	1	13	2		32	1		4		6
Pomoxis spp.											
Largemouth bass	2	1				1			2		3
Spotted bass											
River darter											
White bass			2	1			1		2		4
Yellow bass		1									
Striped bass									9		
Morone spp.											
Freshwater drum	4	1	1	1		4			7		3
Total number	125	36	83	49	1,353	159	101	1,752	93	533	159
Species in gear	15	14	9	12	10	15	12	9	11	9	10
Species in habitat		19			25			30		20	

* Habitat acronyms are defined in Figure 1. Gear types: ES = electroshocker, HN = hoop net,

Table 5

lected from the Arkansas River, September 1982, by Habitat and Gear Type*

DFB POOL 1			DFB POOL 2			DFB BAR	NBB	NBT	RVB	RVH	TCC			TCT			
ES/HN	EG	SN	ES/HN	EG	SN	ES/HN	ES/HN	ES/HN	ES/HN	ES/HN	ES/HN	EG	SN	ES/HN	EG	SN	TOTAL
	1		1	1				1			1	1					10
1	6			2		1		3		1	6	5					30
											1	1		1	6		23
																	0
																	3
132	72	4	194	34		62	19	82	27	34	405	16	27	65	89		1,595
1		7									4			18			35
	14			1						1	4	1			1		29
													3				3
														1			1
																	0
2								2		1		2					14
		269			164								385			51	1,597
		331			235								873			59	2,456
		1															2
					31								4			1	60
																1	2
		10			5								3			1	21
		22			34								12			4	87
																1	1
																	0
													1				1
																	3
		137			39								219			97	581
		7											1				8
	15			7		1	1	2	2	1		23		3	1		103
																	9
																	0
										1							1
																	2
																	1
																	0
3	21			10		1	2	23		5	2	23		4	48		180
	9			11				2		1		8			4		49
							3	2	8	6	1						25
		921	3		1,432								1,285			593	5,970
		7			5								2				81
																	5
														1			1
4		5	4			1	15	11	24	65	2		4	7		13	179
									5								7
			1				5	16	15	29	2		1	8			82
									1	1							3
																	0
		1			2								12			2	25
			1	1		1	1	1	3	2	2	1		1			25
6	2		21			8	19	10	21	18	23	7		17	1		223
													1				1
3			2			2	2	2		1	5	1		2			26
																	0
																	0
4	1					1		6	2	5				5			30
	2			1			1					1			1		7
				1		4		1	1	2	1	1					20
																	0
3	3		3			2	3	9	7	7	2	17		5	18		97
159	146	1,722	230	69	1,947	84	71	173	116	181	461	108	2,833	138	169	823	13,714
10	11	11	9	10	8	11	11	16	12	18	15	15	13	14	9	10	
		23			23	11	11	16	12	18			28			26	42

et, EG = experimental gill net, SN = seine.

Table 6

Arkansas River Macroinvertebrate Summary (Rock Baskets)*

Taxon	Habitat							
	DFA		DFB		RVH		RVB	
	Jul	Sep	Jul	Sep	Jul	Sep	Jul	Sep
Insecta								
Diptera								
Chironomidae								
Polypedilum illinoense	X	X		X	X		X	
Polypedilum nr. *scalaenum*	X	X	X		X	X	X	X
Polypedilum convictum	X		X		X		X	
Polypedilum halterale				X		X	X	X
Dicrotendipes nervosus (Type I)	X	X	X	X	X	X	X	X
Dicrotendipes nervosus (Type II)	X	X	X	X	X	X	X	X
Dicrotendipes neomodestus	X	X	X	X	X	X	X	X
Parachironiomus carinatus		X		X		X		X
Glyptotendipes sp.	X	X	X	X	X	X	X	X
Cryptochironomus				X	X		X	X
Xenochironomus sp.						X	X	
Stenochironomus sp.			X				X	
Rheotanytarsus sp.	X				X		X	
Tanytarsus sp.		X	X	X	X	X	X	X
Cladotanytarsus sp.		X		X		X	X	X
Pseudochironomus sp.	X		X	X		X	X	X
Cricotopus bicinctus							X	X
Cricotopus intersectus			X					
Cricotopus festivellus							X	
Nanocladius distinctus	X	X		X	X	X	X	X
Orthocladius sp.		X		X		X	X	X
Paracladopelma sp.							X	
Ablabesmyia parajanta	X	X	X	X		X	X	X
Psectrocladius psilopterus gr.							X	
Coelotanypus sp.							X	
Endochironomus nigricans					X		X	
Trichoptera								
Hydropsychidae								
Hydropsyche orris	X	X	X		X	X	X	
Cheumatopsyche sp.	X		X		X		X	
Potamyia flava			X		X		X	

(Continued)

* Habitat acronyms are defined in Figure 1.

(Sheet 1 of 3)

Table 6 (Continued)

Taxon	Habitat							
	DFA		DFB		RVH		RVB	
	Jul	Sep	Jul	Sep	Jul	Sep	Jul	Sep
Polycentropodidae								
Neureclipsis crepuscularis	X				X		X	
Cyrnellus fraternus	X	X	X	X	X	X	X	X
Ephemeroptera						X		
Caenidae				X				
Caenis sp.		X		X		X	X	
Ephemeridae								
Hexagenia spp.				X	X	X	X	X
Heptageniidae								
Stenacron integum			X		X		X	X
Stenonema interpunctatum			X		X		X	X
Baetidae								
Baetis sp.	X	X		X	X	X		X
Odonata								
Zygoptera								
Coenagrionidae								
Argia moesta	X				X	X	X	X
Anisoptera								
Corduliidae								
Neurocordulia molesta		X				X		X
Macromiidae								
Macromia illinoiensis		X			X			
Didymops transversa		X		X	X	X	X	X
Gomphidae								
Gomphurus sp.				X		X		
Dromogomphus sp.		X						
Amphipoda								
Corophidae								
Corophium lacustre	X	X	X	X	X	X	X	X
Gammaridae								
Gammarus faciatus					X		X	

(Continued)

Table 6 (Concluded)

Taxon	Habitat							
	DFA		DFB		RVH		RVB	
	Jul	Sep	Jul	Sep	Jul	Sep	Jul	Sep
Lepidoptera								
Pyralidae						X		
Pelecypoda		X			X	X	X	X
Unionidae					X			
Quadrula sp.							X	
Leptodea fragilia		X						
Corbiculidae								
Corbicula fluminea	X	X	X	X	X	X	X	X
Gastropoda								
Physidae								
Physa sp.								X
Nematoda					X	X		X
Turbellaria								
Planariidae								
Dugesia tigrina					X	X	X	
Oligochaeta								
Tubificidae								
Tubificidae immature					X	X	X	X
Naididae					X	X		
Dero abranchia						X		X
Dero digitata						X		X
Dero nivea								X
Dero trifidia		X						
Bratislavia bilongata						X		
Paranais littoralis								X
Nais pardalis		X				X		X
Nais variabilis					X			
Stephensoniana trivandran							X	
Nais sp.					X			
Hirudinea					X			
Glossiphonidae								
Placobdella parasitica					X	X		

(Sheet 3 of 3)

Table 7

Macroinvertebrate Data Summary for June 1982 (Bottom Grabs)*

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Insecta							
Diptera							
Chironomidae							
Polypedilum illinoense	X	X	X		X	X	X
Polypedilum nr. *scalaenum*	X	X	X				
Polypedilum convictum	X				X		
Dicrotendipes nervosus (Type I)	X	X	X				X
Dicrotendipes neomodestus	X						
Glyptotendipes sp.	X	X			X		X
Stenochironomus sp.	X					X	
Cryptochironomus sp.	X	X	X		X	X	
Xenochironomus sp.	X	X	X	X	X		
Pseudochironomus sp.	X						
Paracladopelma sp.	X						
Rheotanytarsus sp.	X						X
Tanytarsus sp.	X						
Paratendipes sp.	X						X
Chironomus sp.	X				X		X
Microchironomus sp.						X	
Chernovskiia orbicus	X						
Cricotopus bicinctus			X				
Cricotopus sylvestris group	X	X					
Epoicocladius flavens	X						
Ablabesmyia parajanta	X	X				X	
Ablabesmyia mallochi	X						
Coelotanypus sp.	X	X			X	X	
Procladius sp.	X	X				X	X
Tanypus stellatus	X	X				X	X
Ceratopogonidae							
Bezzia, Probezzia complex	X	X	X		X		
Chaoboridae							
Chaoborus punctipennis	X	X			X	X	
Tabanidae		X					
Trichoptera							
Hydropsychidae							
Hydropsyche orris			X				

(Continued)

* Habitat acronyms are defined in Figure 1.

(Sheet 1 of 3)

Table 7 (Continued)

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Polycentropodidae							
Cyrnellus fraternus		X	X	X			
Neureclipsis crepuscularis	X	X					X
Ephemeroptera							
Ephemeridae							
Hexagenia spp.	X	X			X	X	X
Caenidae							
Caenis sp.	X	X	X				
Odonata							
Anisoptera							
Coenagrionidae							
Argia moesta	X	X					
Zygoptera							
Libellulidae							
Perithemis sp.	X						
Coleoptera							
Coptotomus sp.						X	
Elmidae							
Stenelmis sp.			X				
Megaloptera							
Sialidae							
Sialis sp.						X	
Amphipoda							
Gammaridae							
Gammarus fasciatus	X	X	X	X	X		X
Corophiidae							
Corophium lacustre	X	X	X	X			
Talitridae							
Hyalella azteca	X	X					
Pelecypoda	X	X	X		X	X	X
Corbicula fluminea	X	X	X			X	X

(Continued)

Table 7 (Concluded)

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Nematoda							
Turbellaria							
Planariidae							
Dugesia tigrina	X	X			X	X	X
Annelida							
Hirudinea	X						
Oligochaeta							
Tubificidae							
Limnodrilus hoffmeisteri	X	X	X	X	X		X
Limnodrilus cervix	X	X			X	X	X
Limnodrilus maumeensis	X	X	X		X	X	X
Limnodrilus claparedianus	X	X	X		X	X	
Limnodrilus udekemianus		X	X				
Branchiura sowerbyi	X	X	X	X	X	X	X
Aulodrilus pigueti	X	X			X		
Aulodrilus pluriseta	X						
Ilyodrilus tempeltoni		X			X	X	
Potamothrix vejdovskyi				X			X
Tubificidae immatures	X	X	X	X	X	X	X
Naididae							
Dero digitata	X				X	X	X
Dero nivea	X						X
Dero flabelliger		X			X		
Dero vaga		X					
Nais communis				X	X		
Nais variabilis							X
Haemonais waldvogei	X						
Ophidonais serpentina	X						
Pristina sp.		X					
Haplotaxidae		X	X			X	
Lumbriculidae	X	X					

(Sheet 3 of 3)

Table 8

Macroinvertebrate Data Summary for September 1982 (Bottom Grabs)*

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Insecta							
Diptera							
Chironomidae							
Polypedilum illinoense		X					
Polypedilum nr. *scalaenum*	X	X	X	X	X	X	X
Polypedilum convictum					X		
Polypedilum halterale	X	X	X	X		X	
Dicrotendipes nervosus (Type I)	X			X			
Dicrotendipes nervosus (Type II)		X					
Dicrotendipes neomodestus	X	X	X	X			X
Parachironomus carinatus	X		X				
Glyptotendipes sp.	X	X	X	X	X		X
Cryptochironomus sp.	X	X	X	X	X	X	X
Xenochironomus sp.			X	X		X	
Stenochironomus sp.				X			
Rheotanytarsus sp.		X					X
Tanytarsus sp.	X	X				X	X
Chironomus sp.	X				X	X	X
Cladotanytarsus sp.	X	X				X	X
Cladopelma sp.			X				X
*Paratendipes ? exquisitus***			X			X	X
Cricotopus sylvestris group	X						
Epoicocladius flavens							X
Nanocladius distinctus	X	X		X			
Tanypus stellatus	X	X			X	X	X
Ablabesmyia annulata	X	X	X		X	X	X
Ablabesmyia parajanta	X	X	X	X	X	X	X
Ablabesmyia mallochi	X						
Coelotanypus sp.	X	X	X		X	X	X
Procladius sp.	X	X	X		X	X	X
Ceratopogonida							
Bezzia, Probezzia complex	X	X	X	X		X	
Chaoboridae							
Chaoborus punctipennis	X	X	X	X	X	X	
Sciomyzidae	X						
Decapoda							
Mysidae							

(Continued)

* Habitat acronyms are defined in Figure 1.
** Called *Chironomus* (*Stenochironomus*) *exquisitus* by Johannsen (1937).

(Sheet 1 of 3)

Table 8 (Continued)

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Taphromysis louisianae	X						
Pelecypoda	X		X	X	X		
Corbicula fluminea	X	X	X	X		X	X
Nematoda							
Turbellaria							
Planariidae							
Dugesia tigrina	X	X	X	X	X		
Ephemeroptera							
Caenidae							
Caenis sp.		X	X				
Pentageniidae							
Pentagenia vittigera			X	X			
Ephemeridae							
Hexagenia spp.	X	X	X	X	X	X	X
Trichoptera							
Leptoceridae							
Oecetis sp.	X	X					
Nectopsyche sp.		X					X
Hydropsychidae							
Hydropsyche orris	X						
Polycentropodidae							
Cyrnellus fraternus	X	X	X	X		X	
Odonata							
Anisoptera							
Gomphidae							
Gomphus sp.				X	X		
Megaloptera							
Sialidae							
Sialis sp.					X		X
Amphipoda							

(Continued)

(Sheet 2 of 3)

Table 8 (Concluded)

Taxon	Habitat						
	DFA	DFB	NBB	NBT	TCC	TCT	ACH
Corophidae							
Corophium lacustre	X	X	X	X		X	X
Annelida							
Oligochaeta							
Tubificidae							
Limnodrilus cervix							X
Limnodrilus maumeensis	X	X	X	X	X	X	X
Limnodrilus claparedianus	X	X	X	X	X		X
Limnodrilus hoffmeisteri	X	X	X	X	X		
Limnodrilus udekemianus		X	X				
Branchiura sowerbyi	X	X	X	X	X	X	X
Aulodrilus pigueti	X	X	X		X	X	X
Aulodrilus limnobius	X						
Aulodrilus pluriseta	X	X	X			X	
Potamothrix vejdovskyi		X					
Ilyodrilus templetoni					X		
Tubificidae immatures	X	X	X	X	X	X	X
Naididae							
Dero digitata	X	X			X		X
Dero nivea		X					
Paranais litoralis	X	X					X
Pristina breviseta	X						
Pristina idrensis	X	X					X
Pristina sp.	X						
Pristina osborni	X						
Pristina aequiseta	X						
Nais pardalis	X	X					
Nais behningi	X						
Nais variabilis	X						
Dero sp.	X	X					
Specaria josinae	X						
Ucinais uncinata	X						
Piquetiella michiganensis	X						
Stylaria lacustris	X						
Haplotaxidae		X			X		X
Lumbriculidae			X				
Hirudinea							
Glossiphonidae							
Helobdella sp.						X	

(Sheet 3 of 3)

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